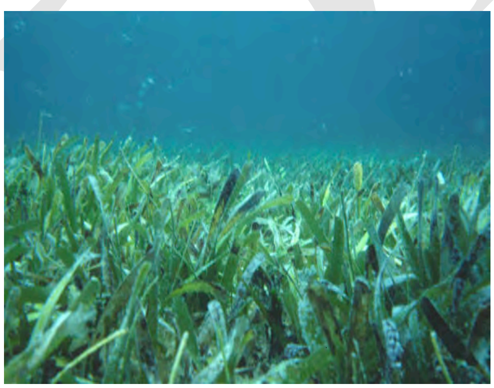
COASTAL AND MARINE ECOLOGICAL CLASSIFICATION STANDARD

VERSION III

FEBRUARY 2009



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Preface

Among the most fundamental questions asked by resource managers about the resources they are trying to manage are 1) what is out there? 2) where is it located? and 3) what is its condition? The “what is out there?” question can be addressed by using well-defined taxonomies (for species) or classifications (for communities and ecosystems) that provide a standard list of potential resource units. The “where is it?” question can be answered by various inventory, remote sensing and mapping techniques that help locate the resource on the landscape or seascape. The “what is its condition?” question can be informed by condition assessment and status and trend monitoring tools. Each of these questions will be addressed by a separate volume in this series.

This volume focuses specifically on the “what is it?” question by describing a new national standard for classifying ecological units in the benthic, sub-benthic, geoform and water column regimes of coastal and marine systems. The document presents the conceptual structure of the classification and the unit definitions forming the basis of inventorying, sampling and mapping activities necessary for management and protection efforts. Companion volumes will describe detailed taxonomic and associative biotopes for each relevant geographic region.

A separate implementation and mapping guidance volume is planned to help answer the “where is it?” question. This volume will cover standards for sampling, inventory, and mapping of the ecological units described here. It will address such issues as appropriate remote sensing technologies, map scales and minimum mapping units, recommended technology, timing, and frequency of sampling, mapping conventions for “split” map classes and best practices for addressing spatially and temporally variable units. A third volume will address methods for answering the “what is its condition” question and will focus on methods for assessing and monitoring the ecological integrity and condition of each of the ecological units defined in this volume.

1. Introduction

Coastal and marine planners and managers are faced with complex challenges in making difficult decisions about habitat conservation and resource management. Given this complexity and recognizing the vastness of the marine environment for which the United States has jurisdiction, there is an urgent and increasing need for a standard national classification for coastal and marine systems. Such a standardized approach can be used to develop strategies for resource management and conservation across North America's coasts and oceans. To meet this need, NOAA and NatureServe developed the Coastal and Marine Ecological Classification Standard (CMECS), a classification standard that is relevant to all U.S. coastal and marine environments and that can be applied locally, regionally and nationally. The continuing goal of the CMECS standard is to permit the classification of ecological and habitat units within a simple standard format that uses a common terminology. This is intended to allow effective identification, monitoring, protection, and restoration of unique biotic assemblages, protected species, critical habitat and important ecosystem components. This classification standard will provide a uniform protocol for identifying and naming new and existing ecological units.

Previous versions of CMECS (Madden et al. 2004, Madden et al. 2005) and a precursor classification framework (Allee et al. 2000) were developed with the input of over 40 coastal and marine habitat experts. CMECS Version III is the product of further refinement and a response to input from additional marine mapping experts. Many refinements in Version III were made to align CMECS with two Federal Geographic Data Committee Standards: 1) the *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al. 1979) – the federal standard for classifying and mapping wetland and deepwater habitats, and 2) The *U.S. National Vegetation Classification* – the federal standard for classifying vegetation (Jennings et al., in press, FGDC 2007). See Appendix I for a discussion of the relationship between CMECS Version III and the existing FGDC wetland standard.

The domain of CMECS Version III encompasses the tidal splash zone of the coasts to the deep ocean, including all continental and ocean waters where ocean-derived salts measure more than 0.5 PSU (Practical Salinity Units), as well as the coasts and deepwaters of the Great Lakes. It encompasses estuaries, tidal wetlands, euhaline and oligohaline rivers, anchialine lakes, shorelines, islands, the intertidal zone, the benthos and sub-benthos and the associated water column.

Guiding Principles

CMECS was designed according to the following principles:

Meet National, Regional and Local Needs

Most existing classification systems have been developed for regional or local applications. The operative scales of these classifications, from tens of meters to thousands of meters, reflect the scale at which many state agencies monitor and manage resources. These local and regional classifications do not readily support the comparison of results across different systems, habitats and classifications nationally. A national classification standard should incorporate the knowledge provided by local classifications and allow aggregation and assessment across diverse systems without any loss of utility at the local level.

CMECS was designed to operate at different spatial scales that may address different objectives. For example, a federal management agency seeking to identify and catalog the benthic habitats of the large estuaries in North America can restrict its analysis to the upper three levels of the benthic classification hierarchy. A local agency classifying habitats within a single estuary may want to use the bottom two or three levels of the benthic classification hierarchy. Using CMECS as a common standard, both agencies will be able to organize and compare results using a unified vocabulary within a common and interoperable data framework. The framework provides the end-user with the tools to build the bottom levels of habitat and biology into the larger conceptual framework.

Build on Existing Work
A goal of CMECS is to integrate both existing data and ongoing data collection efforts to ensure that existing data and knowledge are reflected in the standard. Few continental-scale classifications currently exist. Examples include the EUNIS system in Europe (EEA 1999, Connor 1997), the Integrated Marine and Coastal Regionalization for Australia (IMCRA 1998), the *Classification of Wetlands and Deepwater Habitats of the U.S.* (Cowardin et al. 1979) and the NOAA classification draft (Allee et al. 2000). CMECS incorporates portions of and articulates with these existing coastal and marine classifications where appropriate. Concepts, units and definitions from these and other classification frameworks such as the classification of potential marine benthic habitats by Greene et al. 2007, and the NOAA Coral Classification (U.S. National Oceanic and Atmospheric Administration 2001) provide input to this classification. CMECS also draws on the concepts identified in other state-level classifications such as the SCHEME system in Florida (Madley et al. 2002) and the marine and estuarine habitat classification for the state of Washington (Dethier 1990).

Create a Comprehensive Ecological Classification
CMECS was developed to provide a comprehensive approach to classify all recognized marine ecological units– similar to the Linnaean goal of classifying and describing all species on earth. It attempts to provide an answer to the question, “what is out there?” As a result, CMECS units (especially lower level units on the scale of a few meters) are not solely defined based on whether they can be identified from remote imagery or other currently available sensing technology. Likewise, CMECS is not constrained to units that are spatially or temporally static. Though spatially and temporally variable units such as phytoplankton blooms provide a mapping challenge, they are included in the classification because they represent real, repeating ecological entities that are of conservation and management relevance.

Meet Mapping Needs
Although CMECS units are not defined on the basis of whether they can be mapped, the mapping of CMECS units will be one of the primary applications of the system, and each classification unit represents a measurable space and can be ascribed to a specific place in the marine realm with defined geographic boundaries. The ability to map each classification unit has been considered during the process of defining the unit, and ease of mapping application

was accommodated wherever possible. Because current mapping technology is limited in the details that can be interpreted, *in situ* data collection will be required for identifying and mapping many of the lower level types.

Allow for a Dynamic Content Standard
CMECS Version III will provide a catalogue of accepted standard types. The classification structure, content, and definitions will grow and evolve with use of the classification and associated development of new information. Following the model of the FGDC vegetation standard, CMECS will be a dynamic content standard (FGDC 2007). The overall structure and format will remain relatively stable, but a formal peer review process will be established for submitting and publishing new types for acceptance into the standard.

Provide Modifiers to Meet Individual Needs
CMECS was developed for application at both national and local scales. Local users may be interested in tracking a finer level of detail on a particular unit than is provided in the standard catalogue of types. To meet this need, CMECS provides a standard list of modifiers that allows users to further parse standard types based on such qualities as substrate, energy, salinity, turbidity or characteristic structural components. This will provide flexibility to local users while allowing them to report on the standard types to meet national reporting needs.

Document Terminology
A glossary of terms representing the official classification nomenclature is an integral part of the classification standard. Universally recognizable and accepted terms for classification descriptors are used, and they replace or translate local vernacular or popular usages.

The Structure and Components of CMECS

CMECS Version III classifies the coastal and marine environment to broadly describe an aquatic setting,, called a System, and provides additional detail through five underlying components that describe different aspects of the relevant ecology. These components provide a structured way to organize information about coastal and marine habitats, and provide a standard terminology for describing them. The CMECS Systems are: Nearshore, Neritic, Oceanic, Estuarine, Freshwater Influenced and Lacustrine. Within each System, the five branches or Components of the classification further define the environment (Figure 1). The Biotic Cover Component (BCC) is a hierarchical classification that identifies the biological composition and cover of the coastal and marine benthos (example types include Clam Bed, Spur and Groove Reef, and Rooted Vascular Vegetation). The Surface Geology Component (SGC) describes the geological composition and environment of the upper few centimeters of benthic or coastal substrate, describing also the structural aspects of biogenic substrates such as coral reefs. The BCC and the SGC are designed to be used together to comprehensively describe the benthic environment and cover as observed or mapped from above. The Sub-Benthic Component (SBC) describes characteristics of the sediments and soils with depth, providing more detailed information on the composition of the entire sediment column. The Geoform Component (GFC) describes the major geomorphic or structural characteristics of the coast and seafloor at various scales (example units include abyssal plain, seamount, delta, and beach). The Water Column Component (WCC) describes the structure, patterns and processes of the water column (example types include depth, water column strata, hydromorphic formation and salinity).

Each component is intended to be identified and mapped independently or combined as needed to inform specific questions or problems, much in the same way that terrestrial ecologists combine separate land cover classifications, landform classifications and soil classifications to inform their work. For example, users that need an inventory of seagrass distribution might only identify and map BCC units. Those interested in mapping “cover” (the features that can be seen when looking at the seafloor from above, at the observational scale of the unaided eye) would use the SGC and the BCC together, following guidance described later in this document. Those interested in the distribution of seamounts might only use the GFC. Users interested in the zonation of biotic communities on seamounts would likely overlay the BCC and GFC to provide additional insight into how benthic patterns vary with the structure of geologic formations. Those interested in modeling how subaqueous soils affect the potential distribution of seagrass would overlay a BCC map with an SBC map. The same users might also overlay a WCC map to understand the interaction between soils and photic quality of the water column and their impact on seagrass distribution. The CMECS components serve to organize similar physical, chemical, and biological information in a way that allows practitioners to assemble maps or answer queries related to specific species associations. How the components could be applied in these ways is discussed in Chapter 9, Applying CMECS in Mapping and Classification.

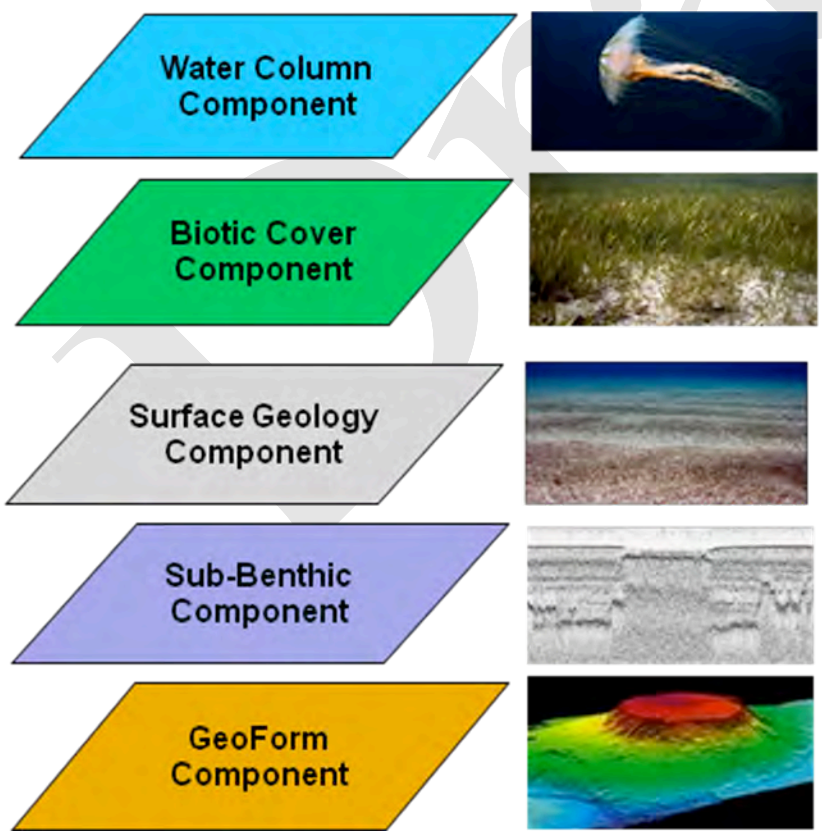


Figure 1. The Five CMECS Components.

In addition to the five components, CMECS provides a list of standard attributes -- a consistent set of variables that provide the basis for classification and description of the CMECS units. When required to define a unit, these standard attributes are called "classifiers." When not required for classification, but used to further describe a unit, these standard attributes are called "modifiers." Modifiers provide users the ability to customize their application of the classification in a standardized way.

Status

Each component of the classification is in different stages of development. The Surface Geology Component follows the Cowardin classification (with some modifications) and is complete to the Subclass level. The Biotic Cover Component framework is complete and all types from System through the Biotic Group level have been identified and described. The concepts of the Biotope level have been developed, but additional work is needed to fully identify and describe the units therein. Some Biotic Group and Biotope units listed in this document are considered "draft" and may be subject to modification as the standard is applied at local levels. The Sub-Benthic Component is in the early stages of development. The framework of the Geoform Component is complete, but additional work may be needed to identify, code, and describe the units at all levels. The framework of the Water Column Component is in the process of being reviewed and refined, and additional work will be completed to develop the rules for combining the classifiers to identify and describe the water column units.

2. System and Subsystem

System and Subsystem represent an overarching level of classification to describe aquatic settings in broad terms that may be relevant to all five of the components of CMECS (Appendix A). The System and Subsystem descriptors are not hierarchically tied to any specific component, but are always used with each component to set the units in the context of their aquatic setting. The System and Subsystem concepts are equivalent to the System and Subsystem concepts in the FGDC Wetland Standard (Cowardin et al. 1979), but have been expanded to include more specific marine settings.

System

Systems are differentiated from one another by a combination of salinity, geomorphology and depth. Salinity is first used to separate the truly marine systems from those influenced by freshwater. Three systems, Nearshore, Neritic and Oceanic, are truly marine -- all having salinities greater than 30 PSU throughout the year (Figure 2). They are distinguished from each other by depth and relative distance from the continental shelf. Two systems, Estuarine, and Freshwater Influenced, are at least occasionally diluted (< 30PSU) by significant freshwater input during the year. The Estuarine and Freshwater Influenced Systems are distinguished from each other by the degree of enclosure by land. The Lacustrine System is used to classify the U.S. Great Lakes[1] and is defined as having salinity less than 0.5 PSU.

Nearshore [NS]

Nearshore Systems are truly marine in character (> 30 PSU throughout the year). The Nearshore System extends from the land margin to the 30 m depth contour. The proximity of land and nearshore processes strongly influences waters and benthos of these systems although the biota and physics are marine. In these systems, water column and benthic processes are strongly coupled to each other. The vertical circulation of the water column generally distributes bottom nutrients and sediments throughout the water column and the photic zone generally extends through a significant portion of the entire water column. This supports the growth of vegetation on the bottom, and so seagrass and macroalgal beds are often found in these systems.

Neritic [NE]

The Neritic System is also truly marine (> 30 PSU throughout the year) and extends from the 30 m depth contour to the continental shelf break, which occurs at approximately at 200 m (100 m – 200 m) water depth. The seaward boundary is at the shelf break, regardless of depth. Neritic waters and benthos are less coupled to terrigenous processes and more strictly marine in character. Depending on shelf morphology, waters at the 30 m isobath can be quite distant from the continent or they may lie relatively close to land. For example in waters offshore of South Carolina and Georgia, the 30 m isobath can be more than 30 mi offshore in some places while the Neritic System along the south Florida coast occurs within a few miles of shore. These systems are strongly influenced by deep ocean biogeochemistry

[1] Refer to Cowardin et al, for classification of other lake systems.

and physical processes and their water columns and benthos are less physically coupled, often reflected in distinct surface and bottom water layers. Because these waters are less influenced by coastal inputs, they are generally clearer than in the Nearshore System. Light penetration in the Neritic System can reach significant depths and often the ocean bottom.

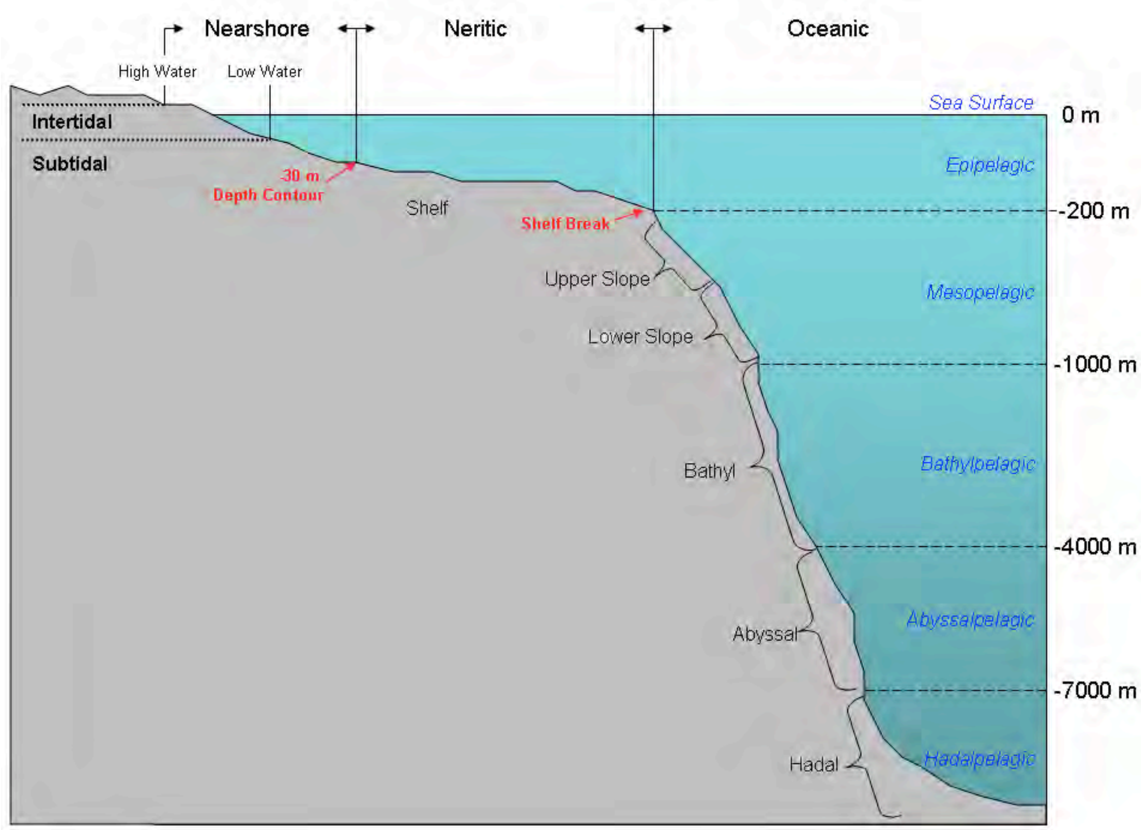


Figure 2. Relationship between Water Column Depth Zones and Benthic Environment. Modified from McGraw-Hill Companies, Inc.

Oceanic [OC]

The Oceanic System has true marine salinity levels (> 30 PSU- although oceanic salinity is typically 35 PSU) and represents the marine realm beyond the continental shelf break, which generally occurs at 100 m – 200 m depth. Water depth in these systems can range from 100 m to several thousand meters. The boundary created by the depth discontinuity at the shelf break establishes strong and identifiable constraints on the processes in the system and represents a logical breakpoint in the classification for the division of major marine systems. The marine waters of the Oceanic System are sufficiently distant from land that they are not significantly influenced by fresh water, nutrient, or sediment inputs, except around islands. With great depth, the sea bottom diminishes in importance in influencing pelagic processes and there is little or no interaction of ocean bottom with the vast majority of the overlying water column. Light is greatly attenuated within the water column and does not reach the bottom. Surface waters do not mix to the bottom and an upper mixed layer is separated from bottom waters by a density gradient or pycnocline generated by a strong temperature or salinity differential. In the case of oceanic islands where a continental shelf is absent, the island itself possesses a Nearshore System to a depth of 30 m and a Neritic System to a depth of 200 m. The Oceanic System is defined in the case of steep-sided islands to begin beyond the shelf break if applicable or where water depth exceeds the 200 m depth contour.

Estuarine [ES]

The Estuarine System consists of tidal habitats and adjacent tidal wetlands and waters that are at least occasionally diluted by freshwater runoff from the land resulting in salinities < 30PSU for part or all of the year. Estuarine Systems are partially or largely enclosed by land and have partial, free or sporadic access to the open ocean. Salinity may be periodically increased above that of the ocean by evaporation. The geomorphology and hydrology of Estuarine Systems determine the degree of physical enclosure, which in turn impact the water residence time governing biological, physical and chemical gradients within the system.

Estuarine Systems can occur on the continental land mass or on islands in waters of any depth, provided they have sufficient enclosure and significant freshwater flow. The Estuarine System extends landward and upstream to the point where ocean derived salts measure less than 0.5‰ during the period of average annual low flow. They extend seaward to an imaginary line closing the mouth of a river, lagoon, fjord or embayment. Although they are coastal features by definition, many Estuarine Systems have water depths much greater than 30 m. In parts of Puget Sound, Chesapeake Bay, and San Francisco Bay, the 30 m isobath is contained within the enclosed area of the estuary, and central channels can be much deeper than 30 m. All areas within the enclosed morphology that generally defines the estuary are classified as Estuarine, regardless of their depth.

Freshwater Influenced [FI]

River or other fresh water discharges flowing directly into the ocean are very different from estuaries whose discharge is restricted as a result of physical enclosure. Freshwater Influenced Systems have no distinct enclosing morphology, yet receive a significant amount of fresh water input from land, reducing salinity to <30 PSU during at least part of the year. In such systems, an unenclosed marine water column may be influenced by fresh water in the form of an active river plume, direct freshwater runoff, diffuse non-point runoff, an advected fresh water lens, mesohaline coastal water mass or a ground water seep discharge. Freshwater Influenced Systems can occur in waters of Nearshore or Neritic System depths, provided the region is influenced by fresh water that reduces salinity to below 30 PSU. Freshwater Influenced systems are generally more spatially and temporally variable than others, being strongly influenced by seasonal outflow from rivers, true estuaries or land and ocean currents (Figures 3 and 4). Because of the frequently stratified nature of waters in this class, Freshwater Influenced Systems may spatially overlay or underlay water of true marine salinities (Nearshore).

Figure 3. Mississippi River plume in the Gulf of Mexico, a Freshwater Influenced System.

Figure 4. Freshwater plume edge.

Lacustrine [LA]

In CMECS, the Lacustrine System only applies to U.S. Great Lakes. For all other lakes, users should consult the National Wetlands Inventory (NWI) classification standard (Cowardin et al. 1979). The Lacustrine System includes the shoreline and deepwater areas of the Great Lakes that lack trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30% coverage. Salinity levels are always less than 0.5 PSU. Unconsolidated and Rocky shorelines, and non-persistent Emergent Wetlands are included in the Lacustrine System. Adjacent persistent freshwater wetlands are part of the NWI Palustrine System and are excluded from CMECS.

Figure 5. Northpoint, MI; rocky shoreline along Lake Michigan.

Subsystem

Subsystems of the CMECS classification are defined by tidal regime- whether or not the area is continuously submerged below the water surface as follows:

For the coastal marine Systems of Estuarine, Nearshore, Neritic, Oceanic and Freshwater Influenced:

Subtidal [1] – The substrate is continuously submerged relative to the extreme low tide line.

Intertidal [2] – The substrate is regularly and periodically exposed and flooded by tides. This zone includes the supratidal zone -- the area above the high tide line in the splash zone that is affected by spray, splash, aerosols and overwash. This interface is regularly exposed to the air by tidal movement. Aquatic organisms inhabiting these physically energetic habitats are adapted to periods of exposure to the air and to wave action. Included in these subsystems is the region of non-tidal wetlands and uplands that are periodically saturated by saline waters at or above the soil surface.

For the Lacustrine System, Subsystems are defined by aquatic depth zones:

Limnetic [1]

All deepwater habitats within the Lacustrine System greater than 2 m.

Littoral [2]

All wetland habitats in the Lacustrine System. Extends from the shoreward boundary of the system to a depth of 2 m below low water or to the maximum extent of nonpersistent emergents, if these grow at depths greater than 2 m.

3. The Surface Geology Component (SGC)

Describing the composition of the substrate surface is a fundamental part of any marine classification scheme. The Surface Geology Component is a first-order characterization of the geology that provides context and setting for many marine processes, and provides soft or hard structure for benthic fauna (Appendix B). The primary focus of the SGC is on the upper layer of hard substrate, or on the upper centimeters of soft sediment. The SGC recognizes that the upper layer of substrate may be geologic or biogenic in origin, and includes those structural settings that have been created by living things, *e.g.*, by corals and other reef-builders. Further, the SGC is designed to interoperate with the BCC to provide an integrated assessment of the physical/geological and biological aspects of benthic "cover". Levels of the SGC finer than those described here (*e.g.*, to classify composition of unconsolidated substrates) are in development in collaboration with the Mapping Partnership for Coastal Soils and Sediment (www.mapcoast.org).

Class and Subclass

Classes and Subclasses for the SGC are determined by the dominant (in terms of percent cover) geologic or biogenic cover of the substrate. Subclasses are defined by the composition and particle size of the substrate, or, in the case of biogenic reef substrates, by reef geomorphology. For consistency with other classification schemes in widespread use, SGC Class and Subclass definitions largely track that of the FGDC Wetland Standard (Cowardin et al. 1979). However, SGC Classes and Subclasses are designed to interplay with BCC Class and Subclass definitions for a flexible approach to physical/geological and biological classifications. SGC Surface Classes and Subclasses represent the non-living components that support the living components described in the BCC, so that (for example) SGC Unconsolidated Bed (Muds) may (or may not) be found associated with BCC Faunal Bed (Ophiuroids or brittle stars). Similarly, the physical structure and setting of an SGC Coral Reef (Reef Crest) may be found underneath a BCC Coral Reef Subclass. Here, the BCC component would further describe the living layer of corals or (if no live corals are present) whatever other biology is colonizing the reef, *e.g.*, macroalgae. This same logic applies to mollusk reefs; the SGC describes only the physical substrate created by mollusks (*e.g.*, an oyster reef), while the BCC describes the biota currently living on that substrate. This biota may be live oysters, or may be attached macroalgae or other colonizers, if the oysters have perished. Where appropriate, classification terms may be repeated in both SGC and BCC Classes and Subclasses; SGC Class Faunal Reef, Subclass Mollusk Reef describes the structural substrate created by mollusks, while BCC Class Faunal Reef, Subclass Mollusk Reef describes the living mollusks, if they are still the dominant life form colonizing that substrate.

Class: Rock Bottom [RB] - Subtidal benthic substrates with 75% or greater cover of large rocks, boulders, pavement, or bedrock.

Subclass: Bedrock **[1] -** Substrate with bedrock covering 75% or more of the surface.

Subclass: Boulder **[2] -** Substrate has less than 75% aerial cover of bedrock, but boulders (>256 mm) alone or in combination with bedrock cover 75% or more of the area. This type corresponds to the Cowardin "Rubble" type.

Subclass: Pavement **[3] -** Substrate has less than 75% aerial cover of bedrock, but pavement -- flat, generally unbroken hard bottom substrate formed by deposition and consolidation of material and overlying a deeper bedrock substrate -- alone or in combination with bedrock covers 75% or more of the area. Sand channels may or may not be present.

Class: Unconsolidated Bottom [UB] - Subtidal benthic substrates having greater than 25% cover of particles smaller than boulders.

Subclass: Cobble/Gravel **[1] -** Greater than 50% of the unconsolidated particles smaller than boulders are cobble/gravel (grain size 2-256 mm). Shell fragments, sands and silt often fill the spaces between the larger particles. Stones and boulders may be found scattered in some cobble-gravel areas.

Subclass: Sands **[2] -** Greater than 50% of the unconsolidated particles smaller than boulders are sands (particles 0.07-2 mm) which may be calcareous, terrigenous, or may derive from some other source.

Subclass: Muds **[3] -** Greater than 50% of the unconsolidated particles smaller than boulders are muds with a grain size < 0.07 mm. Muds may include clay, silt, or carbonate muds. Muds often have a higher organic content than cobble-gravel or sand areas.

Subclass: Organic **[4] -** Unconsolidated substrate largely comprised of decomposing particles of dead plant and animal tissue.

Subclass: Shell **[5] -** Substrate that is dominated by and composed of small bits of broken shell remnants.

Subclass: Mixed Sediments **[6] -** A relatively homogeneous mix of sediment sizes where no single unconsolidated substrate type represents more than 50% of the total composition. The mixed sediments subclass is <u>not</u> to be applied when two or more homogenous polygons of a single substrate type unit, each smaller than the minimum mapping unit, occur adjacent to one another. In this case, the user may use the "split class" mapping convention described in the FGDC Wetland Mapping Standard (2009).

Class: Rocky Shore [RS] - Exposed intertidal shoreline characterized by bedrock or boulders which singly or in combination have an aerial cover of 75% or more.

Subclass: Bedrock **[1] -** Substrate with bedrock covering 75% or more of the surface.

Subclass: Boulder **[2] -** Substrate has less than 75% aerial cover of bedrock, but boulders (>256 mm) alone or in combination with bedrock cover 75% or more of the area. This type corresponds to the Cowardin "Rubble" type.

Subclass: Pavement **[3] -** Substrate has less than 75% aerial cover of bedrock, but pavement -- flat, generally unbroken hard bottom substrate formed by deposition and consolidation of soft material and overlying a deeper bedrock substrate -- alone or in combination with bedrock covers 75% or more of the area.

Class: Unconsolidated Shore [US] - Exposed intertidal unconsolidated shoreline having greater than 25% cover of particles smaller than stones.

Subclass: Cobble/Gravel **[1] -** Greater than 50% of the unconsolidated particles smaller than boulders are cobble/gravel (grain size 2-256 mm). Shell fragments, sands, and silt often fill the spaces between the larger particles. Stones and boulders may be found scattered on some cobble-gravel shores or benthos.

Subclass: Sands **[2] -** Greater than 50% of the unconsolidated particles smaller than boulders are sands (particles 0.07-2 mm) which may be either calcareous or terrigenous in origin.

Subclass: Muds **[3] -** Greater than 50% of the unconsolidated particles smaller than boulders are muds, with a grain size < 0.07 mm. Muds may include clay, silt or carbonate muds. Muds often have a higher organic content than cobble-gravel or sand areas.

Subclass: Organic **[4] -** Unconsolidated substrate is largely comprised of decomposing particles of dead plant and animal tissue.

Subclass: Shell **[5] -** Substrate that is dominated by and composed of small bits of broken shell remnants.

Subclass: Mixed Sediments **[6] -** A relatively homogeneous mix of sediment sizes where no single unconsolidated substrate type represents more than 50% of the total composition. The mixed sediments subclass is not to be applied when two or more homogenous polygons of a single substrate type unit, each smaller than the minimum mapping unit, occur adjacent to one another. In this case, the user may use the "split class" mapping convention described in the FGDC Wetland Mapping Standard (2009).

Class: Coral Reef [CR] – Areas characterized by a substrate or environmental setting largely constructed by the reef-building activities of corals (shallow tropical, deep, or coldwater) and associated organisms. Live corals may or may not be present. Subclasses are based on classical coral reef zonation from large scale geomorphological structures. Below Subclass, the Coral Reef classification includes a Reef Morphology level that describes smaller scale coral reef geomorphology. This way, from a mapping perspective, a polygon for a given Reef Morphology will always be contained entirely within a polygon of a given Subclass. The SGC classifications define coral reef settings through non-living but biogenic physical structure and arrangement, and are intended to be used together with the BCC classifications of living organisms. In one example, SGC classifications can be used to describe a "standing dead" coral reef that no longer supports live corals, while BCC classifications can be used to describe the biology (*e.g.*, macroalgae) that colonizes the non-living (but biogenic) coral substrate. This is further illustrated in Chapter 10, Code Structure.

Subclass: Reef Lagoon [1] – The geomorphological depression found between the reef flat/crest (where developed) or the forereef and shore. Depths commonly range from 0-50 m, and the environment is very low energy, resulting in the accumulation of sediments, typically finer grained than other zones of the reef. Turbidity is often higher in the lagoon than other reef zones.

Subclass: Back Reef [2] – An area that exists landward of the reef flat/crest. This zone differs from the reef lagoon in that it is defined by the geomorphological structure building up to the reef flat/crest. Depths typically range from 1-10 m.

Subclass: Reef Flat [3] – An area or zone immediately landward or lagoonward of the reef crest, most typically found on Pacific reefs or atolls. This zone has almost no slope, and rapidly decreasing energy landward/lagoonward of the reef crest. Depths typically range from 0-3 m, and this reef zone can be intertidal with periodic subaerial exposure. When well developed, this zone can be hundreds of meters wide.

Subclass: Reef Crest [4] – The zone of the reef that reaches closest to the surface of the water and has the greatest exposure to wind and wave energy. This zone is frequently intertidal with periodic subaerial exposure. Depths range from 0-3 m. In most locations, this zone is relatively narrow (*e.g.*, only a few meters to few tens of meters wide).

Subclass: Forereef [5] – This reef zone represents the section immediately seaward of the reef crest (where developed) or the beginning of significant reef development at the seaward end of a lagoon (where the reef crest is not developed). Depths range from 3-30 m and the slope is 0-5°. Much of the shallower portion of this zone is exposed to moderate wave energy, but the deeper portions are below fair weather wave base.

Subclass: Deep Forereef [6] – An area associated with the forereef, but differing from the forereef zone in position (seaward of the forereef), depth (typically 20-60 m), and slope (>30°). Because of the steeper slopes, deep forereefs seldom have substantial accumulation of sediments.

Subclass: Pinnacle Reef [7] – Reefs that are typically physically separated from the shelf reef zonation described by [1] through [6]. Pinnacle reefs rise sharply out of much deeper water, but never develop a bank-like, relatively flat top. If a pinnacle reef does not rise above a depth of 30 m, it falls into the Mesophotic Reef [8] Subclass. Examples are "French Cap" south of St. Thomas (USVI), and parts of the Flower Garden Banks NMS.

Subclass: Mesophotic Reef [8] – Reefs that are found in depths of 30-100 m. They differ from Deep Forereef [6] primarily by their typically very low slopes (0-5°). Mesophotic reefs are commonly dominated by platy hermatypic corals in broad aggregate reef or linear reef features. Examples are "Sherwood Forest" on Dry Tortugas Bank (Florida) in 30-50 m depth and Pulley Ridge (Florida) at a depth of 60-70 m.

Subclass: Deep/Cold Water Reef [9] – Reefs or biogenic substrate constructed by slow growing and fragile accumulations of corals. Such reefs are known to exist in shallow or deep waters, in high latitudes, and to depths of >1,000 m. These reefs typically cap deep seamounts or high latitude banks. The communities found on these reefs differ greatly from those found on [1] through [8] above.

Subclass: Outlier Reef [10] – Reefs that are physically separated from the shelf edge by a trough and display reef geomorphology described by [1] through [6]. Outlier reefs are positioned in close vicinity to modern reefs, but are no longer actively accreting. These reefs often display the range of classic zones from the paleo-lagoon, to paleo-backreef, to paleo-reef crest, and paleo-forereef which typically stopped accreting during a sea level change that led to reef "backstepping." Examples include the series of outlier reefs in the lower Florida Keys where the entire range of reef zonation is evident, but the paleo-reef crest is at a depth of 15-20 m, and no longer meets the definition of a reef crest. These reefs are typically covered by coral reef biotopes, but the current biotopes are different from those that built the outlier reefs.

Reef Morphology. This level describes different geomorphologies of the coral reef setting that occur at a smaller scale than Subclass. Reef Morphologies are associated with Subclasses, and can be mapped within Subclass polygons.

Reef Morphology: Spur & Groove Reef [a] – This geomorphology is also known as reef buttresses. Finger-like reef formations rise >1 m above the surrounding substrate (typically unconsolidated sand). Buttresses (spurs) are typically aligned perpendicular to the reef crest or shore (when no reef crest is developed). This Group is most commonly found in the Forereef [5] Subclass, but can be found occasionally in other Subclasses.

***Reef Morphology: Patch Reef [b]* –** Reefs that are somewhat isolated, relatively circular to amoeboid reef accretions spanning one meter to tens of meters. Patch reefs typically rise 1-10 m above the surrounding substrate, and in many cases are circled by a sand "halo". This Reef Morphology most commonly occurs in the Reef Lagoon [1], but can also be found in the Forereef [5], Mesophotic [8], and other Subclasses.

***Reef Morphology: Aggregate Patch Reef [c]* –** Reefs that are patch reefs spaced too closely to resolve as individual patch reefs at the map scale, or is patch reefs which were clearly distinct reefs at one time, but have now grown together. This Reef Morphology occurs in similar conditions as [b] above.

***Reef Morphology: Linear Reef [d]* –** Linear reef typically fringes shorelines or forms in deeper water (3-20 m) as the terminus of a Reef Lagoon [1]. Linear reef relief can be 1-10 m above the surrounding substrate, and is typically oriented parallel to shore. Reef crests [4] are almost always linear reef by definition. This Reef Morphology occurs most commonly in Reef Lagoon [1], Reef Crest [4], and Forereef [5] Subclasses, and rarely in others.

***Reef Morphology: Aggregate Reef [e]* –** This Reef Morphology encompasses most low to moderate relief amorphous reef geomorphologies that do not readily fall into other Reef Morphologies. Aggregate reefs may have small sand patches contained within the larger reef complex, and are generally found in the Reef Lagoon [1], Back Reef [2], Forereef [5], and Mesophotic Reef [8] zones.

***Reef Morphology: Live Hardbottom [f]* –** Live hardbottom is low relief to very low relief rocky substrate that is or *could potentially be* covered with >10% living coral reef community species. This Reef Morphology is distinct from Pavement found under Rocky Bottom [RB] based on living cover or occurrence in a coral reef environment. Live hardbottom is common in the Back Reef [2], Reef Flat [3], Reef Crest [4], and Forereef [5]. In Florida, it is likely to be composed of limestone, but in island settings, it can be limestone or volcanic rock.

***Reef Morphology: Scattered Coral/Rock on Unconsolidated Bottom [g]* –** This Reef Morphology is defined by individual coral colonies found in unconsolidated substrate. In some cases, the unconsolidated sand is typically only a few centimeters deep, and the corals are actually attached to rock beneath. This Reef Morphology is often located at the seaward edge of the Forereef [5] if it terminates into a sand plain, but it can also be found in the Reef Lagoon [1], and Back Reef [2], or associated with sparse seagrass beds.

***Reef Morphology: Unconsolidated Sands [h]* –** This Reef Morphology type is used within the Reef Lagoon or similar SGC Coral Reef Subclasses, where the overall setting is defined as a Coral Reef by past or present activities of reef-building corals, but the substrate is composed primarily of unconsolidated sand sediments (particles 0.07-2 mm).

***Reef Morphology: Unconsolidated Muds [i]* –** This Reef Morphology occurs within a Reef Lagoon or similar SGC Coral Reef Subclass, where the overall setting is defined as a Coral Reef by past or present activities of reef-building corals, but the substrate is composed primarily of unconsolidated mud sediments with a grain size < 0.07 mm.

Class: Faunal (non-coral) Reef [FR] – Areas where an extensive structural substrate is largely composed of biogenic materials formed by the colonization and growth of mollusks, polychaetes, or any fauna other than corals. Corals are described as a separate class due to their global importance in reef building. Importantly, this class within the SGC describes the structural component of faunal reefs, as a class of surface substrate. The SGC does not consider the living component that currently colonizes the substrate; live reef-building fauna may or may not be present. In one example, an oyster reef may no longer support live oysters, but may still provide an attachment substrate for other biota, *e.g.*, attached macroalgae or mixed colonizers. The oyster reef as substrate is captured as SGC Class Faunal Reef and subclass Mollusk Reef, and any overlying biology is captured in the BCC. The BCC uses the same names to classify living mollusk reefs as the SGC uses to classify mollusk reef substrate, so when live oysters are present on top of an SGC substrate-defined oyster reef, the BCC Class and Subclass is also Faunal Reef and Mollusk Reef.

***Subclass: Mollusk Reef* [1] -** Consolidated structures built by mollusks, usually bivalves (*e.g.*, oysters, mussels) or gastropods (*e.g.*, vermetids). Structures may also result from the geologic consolidations of large deposits of non-reef building mollusk fauna (*e.g.*, Turritellids, *Coquina*) into solid substrate.

***Subclass: Worm Reef* [2] -** Relatively stable ridge-like or mound-like aggregations formed by the colonization and growth of worm species, *e.g.*, sabellariids.

4. The Biotic Cover Component

The biological component of CMECS is a classification of the biotic aspects of substrate at different spatial scales, and is intended to be used together with the SGC so that biology is considered in the context of physical habitat. The Biotic Component is organized into a branched hierarchy of four nested levels. Classes and Subclasses largely adopt the values in the FGDC wetland classification standard (Cowardin et al. 1979) although some definitions have been modified to accommodate uniquely marine characteristics (see Appendix I). Biotic Groups are functional descriptions of biology intended for widespread applicability, e.g., Oyster Reef, Poly/Euhaline Seagrass Bed. Biotopes are repeatable and characteristic assemblages of organisms together with the physical habitats that support their existence. BCC biotopes are identified by dominant or diagnostic species and provide a detailed reporting of the biological and physical components that form close associations in specific geographic regions. See Appendix C for a table of the BCC hierarchy and Chapter 8 and Appendix H for descriptions and a table of Standard Attributes, respectively.

Class and Subclass

Classes and Subclasses are determined by the dominant (in terms of percent cover) biotic cover of the substrate. Class and Subclass definitions track that of the FGDC Wetland Standard (Cowardin et al. 1979) but see Appendix I for a discussion of departures from this standard. Reef Subclasses are largely based on the NOAA Coral Classification (U.S. National Oceanic and Atmospheric Administration 2001). In classifying reef-building biota, BCC Classes and Subclasses may use the same terms as SGC Classes and Subclasses. In these situations, the SGC terms describe the biogenic substrate that was created by reef-building organisms (which may or may not still be present) while the BCC terms describe the biota that is currently living on the substrate.

Class: Faunal (non-coral) Reef [FR] - Living mollusks, polychaetes, or any reef-building fauna (other than corals) colonizing ridge-like or mound-like structures or beds formed by the growth of conspecifics. Corals are described below as a separate class due to their global importance in reef building. In order to be classified as a Faunal Reef, colonizing organisms must be judged sufficiently abundant to construct identifiable biogenic substrate; otherwise, the biotic feature is classified as a Faunal Bed (see below).

> ***Subclass: Mollusk Reef*** **[1] -** Consolidated aggregations of living and dead mollusks, usually bivalves (*e.g.*, oysters, mussels) or gastropods (*e.g.*, vermetids) attached to their conspecifics.
>
> ***Subclass: Worm Reef*** **[2] -** Relatively stable ridge-like or mound-like aggregations of living and non-living material formed by colonization and growth of worm species, *e.g.*, sabellariids.

Class: Coral Reef [CR] - Areas dominated by biology that is closely associated with the structures and settings created by activities of hermatypic (reef building) corals. This includes biology defined through hermatypic corals, but also includes biology defined though other biota that contribute to reef-building, including calcareous algae, etc. When living corals are no longer present on reef substrate due to disease, predation, or other factors, the coral setting is captured in the SGC Coral Reef Class and the (non-coral) biological component is captured as a BCC Faunal Bed (*e.g.*, mixed colonizers) or Aquatic Bed (*e.g.*, macroalgae), see text below. Some Coral Reef types (*e.g.*, Rhodolith Beds) can also exist outside of coral reef settings; they are defined as Coral Reef biological types when they are closely associated with living or non-living coral reef settings.

> ***Subclass: Living Stony Coral Communities [1]*** **-** Areas where live stony corals (including shallow water reef-building corals and deep-water stony corals) constitute 10% or more of the living cover.
>
> ***Subclass: Calcareous Algal Communities [2]*** **–** Coral reef areas dominated by calcareous algae, including prostate (crustose) forms and upright forms, that may contribute either to reef building or to sediment production. Living stony corals constitute less than 10% cover. Rhodolith beds are included in this subclass when they exist as part of a coral reef setting.

Class: Faunal Bed [FB] - Subtidal or intertidal bottoms with a dominant cover of sessile, infaunal, or slow moving animals and associated biota, and less than 10% cover of another structural biotic class (Faunal Reef, Coral Reef, Aquatic Bed). Faunal Bed organisms are obligately hydrophilous but may be able to withstand periods of exposure to air. Faunal Bed taxa differ from those same taxa in a Faunal Reef (see above) in that organisms in a Bed feature are not sufficiently abundant to construct identifiable biogenic substrate. The division of Faunal Bed into Sessile and Mobile Epifauna and Infauna recognizes that, while most biota can be assigned in a straightforward manner, nature provides a continuum of ecologies, and many biota are difficult to categorize clearly, *e.g.*, fauna which are capable of movement but generally do not move, or animals which spend time both above and underneath the sediment surface. Guidance is provided to produce consistent classifications.

> ***Subclass: Sessile Epifauna*** **[1] -** Faunal Bed areas where sessile epifauna are the dominant cover community. Sessile epifauna are defined as organisms that live attached to a hard or soft substrate, with the majority of their body lying above the substrate or sediment surface. Examples include anemones, sponges, hydroids, or other colonizers on hard substrates as well as sedentary mollusks, tube-dwelling amphipods, worms, or anemones living on soft substrates, often partly buried, but with the majority of their body above the soft sediment surface.
>
> ***Subclass: Mobile Epifauna*** **[2] -** Faunal Bed areas where slow-moving epifauna are the dominant cover community. Slow-moving epifauna are defined as motile organisms that cannot move outside of the boundaries of their biotope in less than one

day. Examples include snails, crustaceans, echinoderms, and other fauna on hard or soft substrates. Biotopes may also be defined by tracks and trails of mobile epifauna if these are the dominant cover feature.

Subclass: Infauna **[3] -** Faunal Bed areas where evidence of infauna (*e.g.*, burrow or tunnel openings, siphon holes, feeding mounds, fecal casts, siphons, palps, tentacles, other feeding appendages) constitutes the dominant cover feature, *e.g.*, in plain view, or, when infauna clearly dominate benthic biomass. Infauna are defined as organisms that live with the majority of their body below the sediment surface, although feeding or respiratory appendages commonly extend into the water column. Examples include burrowing polychaetes such as Nereids or Maldanids, tunneling crustaceans such as *Upogebia* or *Squilla*, clams that live underneath the sediment surface, and more.

Class: Aquatic Bed [AB] - Vegetated or microbially-dominated subtidal or intertidal bottoms, or, any area (which might otherwise be classified as a Faunal Bed) that is characterized by greater than 10% cover of vascular plants, attached macroalgae, or microorganisms (and associated biota). Bed organisms are obligately hydrophilous, but may be able to withstand periods of exposure to air.

Subclass: Macroalgae **[1] -** Aquatic beds dominated by macroalgae such as kelp (Figure 6), fucoids, drift algae, or other seaweeds. Macroalgal communities can exist at all depths within the photic zone wherever conditions are appropriate. Macroalgal communities associated with reef structures are classified under the Coral Reef: Non-calcareous algal reef communities subclass. Faunal communities associated with macroalgae are often species-rich, and may include specialized grazers and their predators. Some macroalgal types describe drift algae or ephemeral algae. When macroalgal types of low temporal persistence exist in conjunction with another BCC Class and Subclass, practitioners should evaluate ecological significance over time as well as percent cover in determining which BCC Class and Subclass to assign to the area. An area where drift macroalgae completely cover a seagrass bed would be categorized in a Seagrass Bed subclass if the practitioner judges that the seagrass is the more permanent and ecologically significant feature.

Figure 6. Macroalgae; Giant kelp forest, coastal California.

Subclass: Rooted Vascular **[3] -** Aquatic beds dominated by submerged rooted vascular species such as seagrasses (Figure 7). Seagrass beds are complex structural habitats which provide refuge and foraging opportunities for abundant and diverse faunal communities. Note: Logically the next code for this group would be "[2]". However we've adhered to the FGDC Wetland Standard code for Rooted Vascular [3] (The FGDC standard uses [2] to refer to freshwater aquatic moss which is not relevant to this classification.)

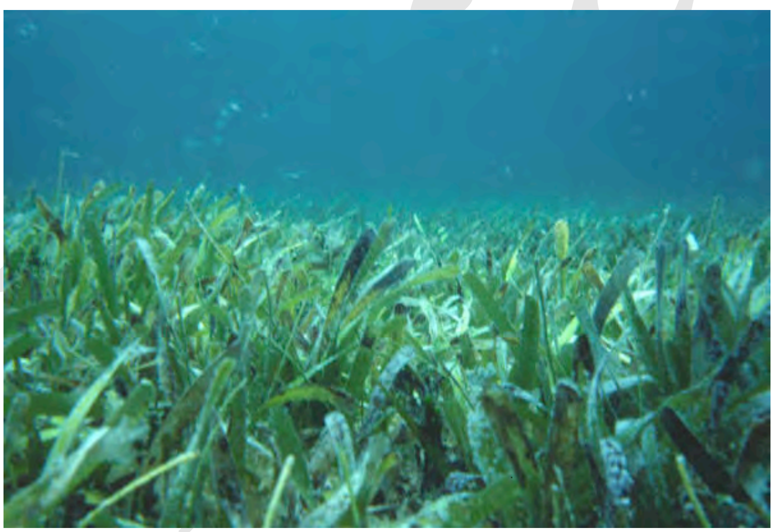


Figure 7. Tropical rooted vascular seagrass bed. Florida Keys National Marine Sanctuary.

Subclass: Microbial Mat **[5] -** Colonies of microscopic organisms that form a visible film, layer, or mat on the surface of the substrate. Colonies may primarily be composed of benthic microalgae (*e.g.*, diatoms), photosynthetic bacteria (*e.g.*, "blue-green algae"), saprotrophic bacteria (decomposers or decay organisms), chemoautotrophic bacteria, or other microbial groups. These features may exist on the surface of the sediment either subtidally or subaerially (Figure 8) or may exist as

extensive areas of decaying dead organisms that have fallen to the seafloor (Figure 9). There may be high levels of biotic diversity within microbial mats. Microbial mats are often encountered in extreme environments where grazing pressure from multicellular organisms is reduced. They can be observed in the high intertidal zone, in areas of low dissolved oxygen, in deep sea areas around thermal vents, and in other locations.
Note: Logically the next code for this group would be "[4]". However The FGDC standard uses [4] to refer to freshwater floating vascular vegetation which is not relevant to this classification. To be consistent with the FGDC wetland standard, we have generated a new code, [5] for Microbial Mat.

Figure 8. Microbial Mat. Tidal flat in Humboldt Bay, California.

Figure 9. Microbial Mat. White clusters of decay bacteria on dead macroalgae in Narragansett Bay, Rhode Island.

Class: Emergent Wetland [EM] - The Emergent Wetland Class is equivalent to the Emergent Wetland Class from the FGDC wetland standard (Cowardin et al, 1979) and is characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants. These environments occur only within the intertidal subsystem While the FGDC wetland standard classification identifies many types of emergent wetlands, only Estuarine coastal salt and brackish marshes are both tidally influenced and have a salinity of 0.5 PSU or greater, and are therefore the only emergent wetlands included in this classification. Tidal freshwater emergent vegetation would be placed in the FGDC wetland standard Palustrine Class and is beyond the scope of this classification. See the USNVC for classification of these communities. Non-persistent emergent Lacustrine vegetation has not yet been addressed.

The Coastal Salt Marsh Subclass is equivalent to the Formation level of the National Vegetation Classification (NVC) – the FGDC standard for vegetation classification. The definition of Coastal Salt Marsh subclass is the same in both the Scrub-Shrub and Emergent classes. The same definitions were maintained to better link the NVC Formation, Group and Alliance level to the FGDC Wetland Standard Class level. This approach also has the advantage of facilitating mapping when shrubs and herbaceous vegetation interdigitate and it is difficult to differentiate between the two classes. The salt marshes dominated by shrubs or trees are placed in the Scrub-Shrub Class and salt marshes dominated by herbaceous vegetation are placed in the Emergent Class.

***Subclass: Coastal Salt Marsh* [1] –** Communities dominated by emergent halophytic herbaceous vegetation or shrubs along low wave energy intertidal areas and river mouths. Salt Marsh is a wetland that has shallow water, and has levels that usually fluctuate due primarily to tides. Coastal salt marshes are primarily intertidal; that is, they are found in areas at least occasionally inundated by high tide but not flooded during low tide. The vegetation is comprised of emergent aquatic macrophytes, especially saline or halophytic species, chiefly graminoids such as rushes, reeds, grasses and sedges, and shrubs and other herbaceous species such as broad-leaved emergent macrophytes, floating-leaved and submergent species (aquatic vegetation), and macroscopic algae. The vegetation is usually arranged in distinct zones of parallel patterns in response to gradients of tidal flooding frequency and duration, water chemistry or disturbance, sometimes described simply as "high marsh" (limits of high tide) and "low marsh" (intertidal marsh.) Salt marshes have gradients that include, barren salt flats at the tidal edge, rushes, and then halophytic herbs and grasses at the outer edge. Daily drawdowns may expose mudflats which contain a sparse mix of pioneering herb and grass species. Salt marsh chemistry is dominated by salinity. Salinity levels vary depending on a complex of factors, including frequency of inundation, rainfall, soil texture, freshwater influence, fossil salt deposits, and other factors. The lower limits of salinity are defined as at least 0.5 PSU, below which it is considered freshwater.

Class: Scrub-Shrub Wetland [SS] - The Scrub-Shrub Wetland is equivalent to the Scrub-Shrub Wetland class of the FGDC wetland standard (Cowardin et al, 1979) and includes areas dominated by woody vegetation generally less than 6 m (20 feet) tall. The species include true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions. Shrub-scrub wetland includes the shrub dominated portions of high salt marshes and tidal salt flats and pannes and stunted or low mangrove communities.

The Mangrove Subclass is equivalent to the Tropical Mangrove Formation of the NVC. The definition of the Mangrove Subclass is the same in both the Scrub-Shrub and Emergent Classes. The same definitions were maintained to better link the NVC Formation, Group and Alliance levels to the FGDC Wetland Standard Class level. Dwarf shrub and short mangroves are placed in the Scrub Shrub Class and tall mangroves are placed in the Forested Wetland Class.

***Subclass: Coastal Salt Marsh* [1] -** Communities dominated by emergent halophytic herbaceous vegetation or shrubs along low wave energy intertidal areas and river mouths. Salt Marsh is a wetland that has shallow water, and has levels that usually fluctuate due primarily to tides. Coastal salt marshes are primarily intertidal; that is, they are found in areas at least occasionally inundated by high tide but not flooded during low tide. The vegetation is comprised of emergent aquatic macrophytes, especially saline or halophytic species, chiefly graminoids such as rushes, reeds, grasses and sedges, and shrubs and other herbaceous species such as broad-leaved emergent macrophytes, floating-leaved and submergent species (aquatic vegetation), and macroscopic algae. The vegetation is usually arranged in distinct zones of parallel patterns in response to gradients of tidal flooding frequency and duration, water chemistry or disturbance, sometimes described simply as “high marsh” (limits of high tide) and “low marsh” (intertidal marsh). Salt marshes have gradients that include, barren salt flats at the tidal edge, rushes, and then halophytic herbs and grasses at the outer edge. Daily drawdowns may expose mudflats which contain a sparse mix of pioneering herb and grass species. Salt marsh chemistry is dominated by salinity. Salinity levels vary depending on a complex of factors, including frequency of inundation, rainfall, soil texture, freshwater influence, fossil salt deposits, and other factors. The lower limits of salinity are defined as at least 0.5 PSU, below which it is considered freshwater. Tidal freshwater emergent are beyond the scope of this classification. See the USNVC for classification of these communities.

Subclass: Mangrove **[2] -** Tidally-influenced, dense tropical or subtropical forest with a shore zone dominated by true mangroves and associates. Mangrove swamps (mangal, mangle) are tidal, estuarine forested wetlands that occur along the (sheltered) coasts of tropical latitudes of the Earth. Their adaptations to cope with seawater include methods of salt secretion, exclusion and accumulation. Physiognomically, they vary in size from dwarf shrubs to tall trees. They are commonly found on the intertidal mud flats along the shores of estuaries, usually in the region between the salt marshes and seagrass beds. Where tidal amplitude is relatively low they form narrow bands along the coastal plains, and rarely penetrate inland more than several kilometers along rivers. Where tidal amplitude is greater, mangroves extend further inland along river courses, forming extensive stands in the major river deltas. Mangrove cays occur also within the lagoon complex of barrier reefs. Non-tidal basin mangrove wetlands are beyond the scope of this classification. See the USNVC for classification of these communities.

Class: Forested Wetland [FO] – The Forested Wetland Class is equivalent to the Forested Wetland Class of the FGDC wetland standard (Cowardin et al, 1979) and is characterized by woody vegetation that is generally 6 m or taller. Though the FGDC wetland standard identifies many types of forested wetlands, only the tidal mangroves are saltwater influenced and are therefore the only forested wetlands included in this classification. These environments occur only within the intertidal subsystem.

Subclass: Mangrove **[2] -** Tidally-influenced, dense tropical or subtropical forest with a shore zone dominated by true mangroves and associates. Dwarf shrub and short mangroves are placed in the Scrub Shrub Class and tall mangroves are placed in the Forested Wetland Class (Figure 10). Mangrove swamps (mangal, mangle) are tidal, estuarine forested wetlands that occur along the (sheltered) coasts of tropical latitudes of the Earth. Their adaptations to cope with seawater include methods of salt secretion, exclusion and accumulation. Physiognomically, they vary in size from dwarf shrubs to tall trees. They are commonly found on the intertidal mud flats along the shores of estuaries, usually in the region between the salt marshes and seagrass beds. Where tidal amplitude is relatively low they form narrow bands along the coastal plains, and rarely penetrate inland more than several kilometers along rivers. Where tidal amplitude is greater, mangroves extend further inland along river courses, forming extensive stands in the major river deltas. Mangrove cays occur also within the lagoon complex of barrier reefs. Non-tidal basin mangrove wetlands are beyond the scope of this classification. See the USNVC for classification of these communities.

Figure 10. Red mangrove forest

Biotic Group and Biotope

CMECS uses the concept of the biotope as the foundation for detailed descriptions of biology. A biotope is a repeatable feature consisting of a physical habitat together with its biological associations. A biotope is uniform in structure and environment, and is identified by diagnostic biology [*i.e.* organisms whose relative abundance or constancy distinguishes one association from another (FGDC 2007)]. The diagnostic organisms can include plants, algae, attached sessile fauna, slowly moving fauna, infauna, and bacterial colonies.

The biotope concept has been employed for several years in Europe and has been defined as the “physical habitat… and its community of animals and plants (Costello 2003).” The primary characteristic of the biotope is the “high fidelity” relationship between the physical habitat and strongly associated diagnostic taxa. Biotope occurrences have similar biotic composition and structure, and must have diagnostic features that enable their recognition repeatably. A taxon or species is used to define and name a biotope if it is conspicuous or dominant, or if it has a high constancy and is physically linked to the habitat. “Non-motile” is defined as an individual organism that cannot move beyond the frame of reference of the habitat unit boundary within one day. Epibenthic organisms like corals, anemones, snails, sponges, or hydroids, and benthic infauna (such as polychaetes or burrowing crustaceans) can define a biotope. For habitats dominated by vegetation such as mangroves, coastal marshes and seagrass beds, the biotope is equivalent to the "Alliance" level of the National Vegetation Classification – "a vegetation classification unit defined on the basis of a characteristic range of species composition, diagnostic species occurrence, habitat conditions and physiognomy" (FGDC 2007).

The principles of the biotope level have been developed, but substantial additional work is needed to refine the descriptions and the physical/biological associations that define regularly-occurring biotopes, particularly as the standard is applied at local levels. Biotopes have not been well catalogued as of this writing, and the CMECS hierarchy includes the more-general Biotic Group level for classifications above biotope. The Biotic Group level is designed for widespread application among different ecoregions, and for use with a variety of sampling methods.

Biotic Groups

Biotic Groups are observational, descriptive, or functional groupings of the characteristic biological types that occur as generalized patterns in many ecoregions. In some cases, Biotic Groups are defined by obvious structure-forming organisms (oyster reef, seagrass bed) but in other cases the defining organisms do not build structural habitat that is obvious to the unaided eye (*e.g.*, clam bed, small tube-building fauna). Identification of biology at the Biotic Group level does not require written descriptions of ecoregion-specific biological/physical associations, does not require a statistical treatment of biotic relationships and co-occurrences, and does not require identification of diagnostic taxa to the species level. The Biotic Group level is quite useful in many areas, and is particularly applicable to many of the poorly-described soft-sediment habitats that constitute the major part of the seafloor. Further, biological classifications at the Biotic Group level are highly comparable among different studies and regions. A significant portion of mapping surveys use optical imaging as one of the primary fine-scale sampling tools, and most Biotic Groups can be determined using many visual methods, including high-resolution plan-view camera images, video camera images, sediment profile images, diver surveys, etc. Because the biotic classification is hierarchical, a broad imaging survey that identifies Biotic Groups can be accompanied by a more detailed collection-based survey to determine biotopes so as to improve understanding of biological/physical associations and interactions.

Resolution, observational scale, and identification of Biotic Groups

Despite several advantages, identification of biology at the Biotic Group level raises certain practical issues. The resolution of the sampling method and the observational scale of sampling both have a significant influence on biological identification, and the two parameters are often (inversely) related. A surface-imaging video camera operated in clear water from 2 meters above the seafloor may image many square meters of seafloor on a drift, and will easily identify megafaunal Biotic Groups – biotic reefs, large epifauna, and evidence of large infauna – but will not provide the resolution to identify macrofaunal Biotic Groups such as *Ampelisca* tubes, forests of spionid palps, or small burrow openings. Conversely, a sampling device with a smaller footprint (*e.g.*, a sediment grab with a "bite" of 0.1 m^2, a sediment profile camera, or a high resolution plan-view still image taken 0.3 m from the surface) may have the resolution to characterize macrofaunal Biotic Groups but will lack the "footprint" required to identify Biotic Groups characterized by larger, more dispersed fauna. Biotic Groups identified with a video camera are not comparable to Biotic Groups identified with a grab sampler. Our method is flexible, and practitioners identify Biotic Groups at the scale allowed by their sampling methods. These issues do not apply to biotope identification, because a catalogue of well-described biotopes will identify the associated macrofaunal and the associated megafauna as the same biotope. In practice, multiple Biotic Groups may be apparent at a sampled point location; this should not be taken as evidence that multiple biotopes are present at that location, particularly when biotopes have not been extensively catalogued and described. In many cases, a single biotope will manifest itself as several Biotic Groups: a clam bed with abundant epifaunal brittle stars might be identified as two biotic groups ("Clam Bed, CB" and "Ophiuroids, OP") while later work might reveal that the two involved species occur in close association as a single identifiable biotope. To address this, data developers may add a second Biotic Group to BCC classifications using the "split class" convention ("Clam Bed/Ophiuroids" or "CB/OP"), but this should be avoided at the Biotope level. Biotope theory predicts that the biological associations at any point location should be identifiable as a single biotope, given complete biotope catalogues based on sufficient biological and physical datasets. In all cases, practitioners must define the observational scale and the resolution of their methods, so that biological information is meaningful and consistent. Importantly, project metadata should clarify which categories of Biotic Groups could not be identified in the project due to limitations in the observational scale and/or the resolution of the sampling gear.

Biotopes

Biotope descriptions provide detailed information on the diagnostic biological fauna as well as on the environmental conditions and other (non-diagnostic) taxa that are associated with the diagnostic taxa. Biotopes are generally limited to specific geographic areas by the distributions of the associated species - - some biotopes may occur in only one ecoregion, while others may occur in a few ecoregions. The defining and associated taxa are generally identified to the species level, and the regularly-occurring physical and biological associations that constitute the biotope are thoroughly explored and described. For some biotopes, information now exists that could be compiled to describe these biotopes at this level of detail. For other biotopes, more effort is needed in the foundational work of developing and analyzing large data sets to statistically categorize biotope associations. This process generally relies upon retrievals of specimens for identification. Statistical methods can then be used to identify regular, repeatable associations among different species and among physical/chemical/geological features in specific geographic locations. Comprehensive regional biotope descriptions have not been completed for this version of CMECS. In the sections that follow, biotopes defined by Genera are hierarchically listed as examples, but no text is provided. The Genus-level biotope names given here can be applied for some project objectives when these biotopes are identifiable, and (as above) a significant amount of descriptive information for many biotopes is available in the scientific literature. Biotopes dominated by vegetation (seagrasses, salt marshes and mangroves) have been defined in the USNVC and these NVC alliance level descriptions will be included soon. Practitioners and other stakeholders are encouraged to suggest additions and refinements, and to propose text for these biotopes through the CMECS website. An example of a developed biotope, and a format for these descriptions, is provided below:

Example Biotope Description:

Biotope: *Phragmatopoma lapidosa* reefs.
U.S. Ecoregions: Floridian.
Description: The brownish mound-like or ridge-like worm reefs that characterize this biotope commonly occur in or just outside the surf zone running parallel to high-energy tropical or subtropical beaches, but may occur in other settings as well. In the United States, this biotope is most common on the Atlantic coast of southern Florida. These reefs have a honeycomb appearance, with a grainy texture that can be crumbled by hand. The diagnostic species, *Phragmatopoma lapidosa*, is commonly known as the "reef-building tubeworm" or "sand-tube worm". These 15 - 40 mm animals cement sand-sized grains of substrate into 5 - 30 cm protective tubes that can form extensive reefs through successive colonization and growth of conspecifics. The reefs are important ecologically, providing refuge and hard substrate in an area of high wave energy. The reefs also play an important geological role by decreasing the effects of wave erosion on shores, and by contributing to the formation and maintenance of barrier islands and beaches.
Physical Associations: This biotope is associated with turbulent, high-energy areas on sand substrates that provide appropriately-sized suspended particles for tube construction and feeding. These conditions are most commonly found at high-energy beaches between the mid-tide level and a depth of 2 m, but can also occur at high-velocity tidal inlets and in other areas, and colonies have been reported at depths to 100 m. Stable attachment sites are required for initial colonization, as larvae have a difficult time settling into unstable shifting sands. Living or dead conspecifics provide a preferred colonization site, but any stable solid object or feature can be used for initial settlement. Most reefs occur in tropical and subtropical areas at euhaline salinities.
Biological Associations: *P. lapidosa* reefs support a complex faunal assemblage with much higher diversity and abundance than can be found in adjacent sandy non-reef areas. A particularly high diversity of crustaceans generally dominates the associated macroinvertebrate community, but many other taxa are abundant: barnacles (*Tetraclita squamosa),* sponges, bryozoans, coelenterates, and mollusks also colonize the reefs. The crabs *Pachygrapsus transversus*, *Mennipe nodifrons*, *Pilumus dasypodus*, or *Panopeus bermudensis* are notable predators on the tube worms themselves. Demersal and semi-demersal fishes (*e.g.*, *Labrisomus nuchipinnis*, *Scartella cristata*, and *Diplodus holbrooki*) are also associated with this biotope. Pistol shrimps (*Synalphus fritzmuelleri*) may be common. Transient visitors foraging in this biotope include a variety of predatory fish, many of which are commercially or recreationally valuable.
Range: Western Atlantic from Florida to Brazil; present (but rare) in the Gulf of Mexico.
Related Biotopes: *Sabellaria vulgaris* reefs are found in the Western Atlantic north of Florida (generally in deeper waters) and constitute a common biotope in Delaware Bay and elsewhere. *Phragmatopoma californica* reefs are found from southern California into Mexico. *Sabellaria alveolata* reefs are found in the Eastern Atlantic (*e.g.*, southwestern England, northern France).
Sources: Zale, A.V., and S.G. Merrifield. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (south Florida) -- reef-

building tube worm. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.115). U.S. Army Corps of Engineers, TR EL-82-4.

Summary

The appropriate level of biological description should be determined based on user needs and project objectives. For broad-scale mapping with rapid sampling tools, the more observational identification to Biotic Group may be well-suited to project objectives. To create maps, the complexities of aquatic biology need to be reduced to a manageable number of meaningful categories so that polygons can be interpolated or modeled. For a number of applications in science and management, identification of biology either descriptively or by function may provide the same benefits as identification of biotopes by species (see, *e.g.*, Grizzle and Penniman 1991). As a practical matter, when biotopes have not been catalogued, Biotic Group may be the only feasible level of biological classification. However, the finer Biotope level of classification will be necessary for many regional projects, and will be necessary when a more meaningful understanding of biological and physical associations is required. The following text describes Biotic Groups for each of the BCC Classes and Subclasses. Biotic Groups are identified, but biotopes have not been catalogued; work to develop biotopes is ongoing. Biotopes are presented here only to provide a few Genera as examples of the diagnostic taxa that may fall under each Biotic Group.

Class: Faunal (non-coral) Reef [FR]

Reef biology at both the Biotic Group and the Biotope levels is defined by the substrate-forming organisms. These groupings also include predators on reef-building fauna (*e.g.*, starfish) and the associated communities.

Subclass: Mollusk Reef

Biotic Group: Oyster Reef [or] - Ridge-like or mound-like structures formed by the colonization and growth of oysters that are attached to a substrate of live and dead conspecifics.
Biotopes: *Ostrea* reef, *Crassostrea* reef

Biotic Group: Mussel Reef [mr] - Ridge-like or mound-like structures formed by the colonization and growth of mussels that are attached to a substrate of live and dead conspecifics.
Biotopes: *Mytilus* reef, *Modiolus* reef

Biotic Group: Gastropod Reef [gr] - Consolidated aggregations of living and dead gastropod mollusks, usually those of the family vermetidae or the genus *Crepidula*.
Biotopes: Vermetid reef, *Crepidula* reef

Subclass: Worm Reef

Biotic Group: Sabellariid Reef [sr] - Ridge-like or mound-like features formed by colonization and growth of living sabellariid worm species that

have cemented sediment grains into complex structures. Certain types of sabellariid reefs most often occur parallel to a shoreline in shallow water, but many are also found in deeper waters.
Biotopes: *Phragmatopoma* reef, *Sabellaria* reef

Class: Coral Reefs [CR]

Biotic Groups and biotopes for the Coral Reef class recognize coral reef areas as structural settings, constructed by living organisms that support life. The living organisms and biotopes currently associated with this coral reef setting may or may not include the hermatypic (reef-building) corals that originally constructed the reef.

Subclass: Living Stony Coral Communities [1]

Biotic Group: Robust Branching Corals [bc] - A description of this Biotic Group is TBD based on input from coral biologists and mappers.
Biotopes: *A. palmata* Reef

Biotic Group: Fragile Branching Corals [fb] - A description of this Biotic Group is TBD based on input from coral biologists and mappers.
Biotopes: *Acropora* Reef, Porites Reef, Madracis Reef, Oculina Reef, Lophelia Reef, Pocillopora Reef.

Biotic Group: Table Corals [tc] - A description of this Biotic Group is TBD based on input from coral biologists and mappers.
Biotopes: *Acropora* Reef

Biotic Group: Massive Corals [ma] - A description of this Biotic Group is TBD based on input from coral biologists and mappers.
Biotopes: *Diploria* Reef, *Montastraea* Reef, *Montipora* Reef, *Porites* Reef

Biotic Group: Plate Corals [pc] - A description of this Biotic Group is TBD based on input from coral biologists and mappers.
Biotopes: *Agaricia* Reef, *Montastraea* Reef

Biotic Group: Encrusting Corals [en] - A description of this Biotic Group is TBD based on input from coral biologists and mappers.
Biotopes: *Millepora* Reef, *Porites* Reef

Subclass: Calcareous Algal Communities [3]

Biotic Group: Rhodolith Beds [rd] - Communities where red crustose algae form biogenic substrate, creating a stable, three-dimensional habitat. The substrate is primarily formed by colonization and growth of these crustose algae.

Biotopes: *Lithothamnion* communities*,* *Lithophyllum* communities

Biotic Group: Crustose Calcareous Algae [cc] - Coral reef areas dominated by calcareous algae with a prostate, encrusting morphology and a stony texture, attached to a (non-algal) coral reef substrate**.**
Biotopes:

Biotic Group: Upright Calcareous Algae [uc] - Coral reef areas dominated by calcareous algae with an upright (often branched) morphology and a stony texture.
Biotopes: *Halimeda* communities*.*

Class: Faunal Bed [FB]

Subclass: Sessile Epifauna

Biotic Group: Oyster Bed [ob] - Areas where the dominant fauna consists of accumulations of oysters scattered on a substrate other than conspecifics.
Biotopes: *Ostrea* communities, *Crassostrea* communities

Biotic Group: Mussel Bed [mb] - Dense accumulations of mussels attached to a substrate other than conspecifics. Includes associated faunal communities and predators on mussels (*e.g.*, starfish), which may be highly conspicuous.
Biotopes: *Mytilus* communities, *Modiolus* communities

Biotic Group: Sessile Gastropods [sg] - Area dominated by sessile gastropods, often filter-feeders or suspension-feeders. Fauna do not occur in abundance sufficient to construct biogenic substrate, as in the Faunal Reef Class.
Biotopes: *Crepidula* communities*,* vermetid communities

Biotic Group: Barnacles [bn] - Communities dominated by barnacles and associated fauna (*e.g.*, *Littorina*) that are attached to or associated with a solid substrate.
Biotopes: *Chthamalus* communities*,* *Balanus* communities

Biotic Group: Coral Garden [cg] - Aquatic beds that are dominated by non-reef forming corals including soft corals, gorgonians (sea fans, sea whips), sea pansies, etc, also including sponges and other sedentary or attached macroinvertebrates. These areas may occur in any setting, including soft substrates, hard substrates, coral reefs, etc. Seagrass cover is less than 10%.
Biotopes: mixed soft coral communities, gorgonian communities

Biotic Group: Mixed Colonizers [xc] - Highly varied communities of fauna that have attached to a biotic or abiotic substrate, which may be rock, cobble,

sand, oyster reef, coral reef, other colonizing organisms, etc. Common colonizing taxa include sponges, anemones, ascidians, barnacles, mollusks, hydroids, bryozoans, and/or other taxa.
Biotopes: coastal Virginian mixed colonizing communities, deep-water Northern Gulf of Mexico mixed colonizing communities

Biotic Group: Sponge Bed [sp] - Areas of the seafloor where the dominant cover fauna consists of sponges and their associated communities. These areas may occur in any setting, including soft substrates, hard substrates, coral reefs, etc. Hexactinellid "glass sponges" are common deep-sea biotopes; other sponge groups may dominate coastal epifaunal communities
Biotopes: *Microciona* communities, *Hyalonema* communities

Biotic Group: Attached Anemones [aa] - Areas dominated by beds of attached anemones that secure themselves to a hard substrate with a pedal disc.
Biotopes: *Metridium* communities

Biotic Group: Burrowing Anemones [ba] - Areas dominated by beds of anemones that burrow in soft substrates
Biotopes: *Cerianthus* communities, *Edwardsia* communities

Biotic Group: Small Tube-Building Fauna [st] - Areas dominated by tube-building spionids, amphipods, or other small surface-dwelling tube-building fauna with a tube width usually less than or equal to 2 millimeters, often occurring in dense mats. The animal itself may reside above or below the sediment surface within the constructed tube. For consistency, tube-building fauna are considered epifaunal if the tube protrudes a distance above the sediment surface that is greater than the width of the tube (regardless of the position of the actual animal, which may not be known).
Biotopes: *Ampelisca* communities, *Polydora* communities, *Streblospio* communities, *Paraprionospio* communities

Biotic Group: Larger Tube-Building Fauna [lt] - Areas dominated by larger tube-builders, primarily polychaetes, with a tube width greater than 2 millimeters. The animal itself may reside above or below the sediment surface within the constructed tube. For consistency, tube-building fauna are considered epifaunal if the tube protrudes a distance greater than its width above the sediment surface, regardless of the position of the actual animal (which may not be known). Certain tube-building species (*e.g.*, *Asabellides oculata* in certain locations) may form extremely dense mounds of tubes that rise many cm above the seafloor. If colonization and growth of these fauna results in the construction of biogenic substrate that is relatively stable, these faunal structures may be classified in the subclass Worm Reef (see above).

Biotopes: *Chaetopterus* communities*,* *Lagis* communities*,* *Diopatra* communities*,* *Asychis* communities*,* *Asabellides* communities*,* *Loimia* communities

Biotic Group: Crinoids [cn] - Assemblages dominated by sessile stalked crinoids or "sea lilies", or by the motile (but often stationary, see Barnes 1980) comatulid "feather stars", common in the deep sea and in other areas.
Biotopes: *Diplocrinus* communities*,* *Comanthus* communities

Biotic Group: Hydroids [hy] - Areas dominated by mounds or mats of hydroid colonies.
Biotopes: *Sertularia* communities*,* *Tubularia* communities

Biotic Group: Bryozoans [br] - Areas where abundant or structurally complex bryozoan communities are habitat-forming. These communities may occur as complex calcareous structures, as fouling communities, as ephemeral drift communities in coastal waters, and in other settings. Certain species of bryozoan may form extensive habitats.
Biotopes: *Bugula* communities, *Celleporaria* communities

Biotic Group: Tunicate Bed [tb] - Areas dominated by members of the subphylum Urochordata, including ascidians, sea squirts, or other tunicates. Some species may be rapid invasives that blanket large areas, *e.g.*, *Didemnem*.
Biotopes: *Didemnum* communities*,* *Molgula* communities

Biotic Group: Foraminifera [fa] - Areas (typically found in the deep sea) that are dominated by tests of large benthic foraminifera protruding visibly from the substrate.
Biotopes: xenophyophore communities

Subclass: Mobile Epifauna

Mobile epifaunal Biotic Groups can be identified by evidence of fauna that is visible at the sediment surface (*e.g.*, tracks or trails) or by the fauna themselves. Analysts should be aware that some mobile epifauna are predators on sessile organisms that are more diagnostic of biological associations at the Biotope level. In one example, starfish are common predators on mussel beds or other fauna; the Biotic Group in this case is best identified at the more diagnostic mussel bed level. Consequently, no Biotic Group is provided to describe the predatory starfish. Similarly, sea urchins are often abundant grazers on macroalgal communities, but the Biotic Group is best identified through the macroalgae as an Aquatic Bed. Mobile epifauna are often associated with another Biotic Group as a single biotope, which may or may not have been described and catalogued. Analysts should be cautious when applying Biotic Groups that may be defined by mobile predators. This section focuses on Biotic Groups that are defined by mobile detritivores or filter-feeders.

Biotic Group: Mobile Gastropods [mg] - Areas where the dominant or distinctive epifaunal taxa are slow-moving gastropods foraging at the sediment surface; these animals may be partly buried.
Biotopes: Nassariid communities, Turritellid communities

Biotic Group: Mobile Crustaceans [mc] - Areas where the epifaunal community is dominated by slow-moving crustaceans. This group is limited to the relatively non-motile epifaunal crustacean taxa (*e.g.*, hermit crabs, amphipods, isopods) and does not include the more mobile crustacean forms such as swimming crabs, penaied shrimp, etc.
Biotopes: *Pagurus* communities

Biotic Group: Scallop Beds [sc] - Areas where dense accumulations of scallops constitute the dominant epifaunal species.
Biotopes: *Argopecten* communities, *Placopecten* communities

Biotic Group: Sand Dollars [sd] - Assemblages dominated by surface-dwelling "irregular" echinoids of the order Clypeasteroida, *e.g.*, sand dollars. Sand dollars typically move on top of the sediment surface or burrow in the top few centimeters of sediment. For purposes of classification these biotopes are placed in the Subclass "Mobile Epifauna"; the closely-related burrowing urchins typically live below the sediment surface and are placed in the Subclass "Infauna". The also-related "regular" urchins or "sea urchins" typically live in close association with another biotope (*e.g.*, as grazers on macroalgae or coral reef) and are considered part of those associated biotopes.
Biotopes: *Mellita* communities, *Clypeaster* communities

Biotic Group: Ophiuroids [op] - Assemblages dominated by burrowing or epifaunal brittle stars. Brittle stars may be epifaunal or infaunal, and these biotopes are repeated in the Infaunal Bed Subclass.
Biotopes: *Ophiura* communities, *Ophiothrix* communities, *Amphiura* communities

Biotic Group: Holothurians [ho] - Assemblages dominated by holothurians or "sea cucumbers", common in the deep sea and in other areas.
Biotopes: *Kolga* communities, *Stichopus* communities

Subclass: Infauna

Infaunal Biotic Groups and biotopes can be identified by evidence of infauna that is visible at the sediment surface (*e.g.*, (burrow or tunnel openings, fecal mounds, fecal pellets, palps, etc). When the area below the sediment surface is sampled, infaunal biotopes can be characterized by the abundance and biomass of the infaunal organisms themselves.

Biotic Group: Clam Bed [cb]- Areas where siphons or siphon holes are the dominant surface feature, or where clams dominate faunal biomass at the

biotope scale. Siphons or shells may or may not be visible from above the sediment surface.
Biotopes: ***Macoma*** **communities,** ***Venus*** **communities,** ***Spisula*** **communities,** ***Mercenaria*** **communities,** ***Mya*** **communities,** ***Nucula*** **communities**, ***Yoldia*** **communities,** ***Mulinia*** **communities,** ***Rangia*** **communities,** ***Arctica*** **communities**

Biotic Group: Tunneling Megafauna [tm] - Areas dominated by burrowing or construction activities of larger organisms that create a water-filled tunnel. Tunneling activities are often attributable to crustaceans, generally decapods, but fish and other taxa may also create large tunnel features. An associated mound of sediment may also be constructed.
Biotopes: ***Squilla*** **communities,** ***Nephrops*** **communities,** ***Upogebia*** **communities**, ***Callianassa*** **communities,** ***Thallassia*** **communities**

Biotic Group: Small Surface-Burrowing Fauna [sb] - Areas dominated by small, burrowing, typically worm-like fauna with a body width usually less than ~ 1.5 mm, typically found within 5 cm of the sediment-water interface. In many cases, individual animals generally associated with this group will be found living deeper than 5 centimeters; they are still classified as small near-surface fauna. Burrowing fauna other than worms may be characteristic, *e.g.*, small surface-burrowing amphipods.
Biotopes: capitellid communities, **oligochaete communities, lumbrinerid communities,** ***Leptocheirus*** **communities**

Biotic Group: Deposit Feeders [df] - Areas distinguished by a fluid fecal-rich pelletized surface layer typically 5 to 15 mm thick (*sensu* Rhoads and Young 1970) that is characteristic of deposit-feeding polychaetes, deposit-feeding clams and/or other fauna.
Biotopes: ***Nucula*** **communities**, ***Yoldia*** **communities,** ***Macoma*** **communities**, **Maldanid communities,** ***Clymenella*** **communities,** ***Pectinaria*** **communities**

Biotic Group: Larger Deep-Burrowing Fauna [db] - Areas where the surface area is dominated by evidence of larger deep-burrowing infauna, or where larger deep-burrowing taxa dominate the infaunal biomass. Characteristic taxa include larger polychaetes or other worm-like fauna, with a body width > 1.5 mm, typically living > 5 cm below the sediment-water interface. Large fecal casts, mounds, burrows, feeding voids, etc, may be taken as evidence of deep-burrowing fauna. However, areas characterized by larger tube-building worms that that construct a significant tube structure rising above the sediment-water interface, but live with a body position below the sediment surface, are classified as Larger Tube-Building Fauna, see above.
Biotopes: ***Nephtys*** **communities,** ***Nereis*** **communities, nemertean communities**

Biotic Group: Burrowing Urchins [bu] - Assemblages dominated by burrowing “irregular” echinoids, *e.g.*, burrowing urchins or heart urchins. These urchins typically live underneath the sediment surface so for purposes of classification these biotopes are placed in the Subclass “Infauna”. The closely-related sand dollars typically live at (or just below) the sediment surface and are placed in the Subclass “Mobile Epifauna”. The also-related “regular” urchins or “sea urchins” typically live in close association with another biotope (*e.g.*, as grazers on macroalgae or coral reef) and are considered part of those associated biotopes.
Biotopes: *Echinocardium* communities*,* *Lovenia* communities

Biotic Group: Ophiuroids [op] - Assemblages dominated by burrowing or infaunal brittle stars. Brittle stars may be either epifaunal or infaunal depending on the species or on environmental conditions, and the Biotic Group “Ophiuroids” is repeated in the Mobile Epifauna Subclass.
Biotopes: *Ophiura* communities*,* *Ophiothrix* communities*,* *Amphiura* communities

Biotic Group: Echiurid Communities [ec] - Communities dominated by echiurids or “spoon worms”, or communities where their burrows constitute the dominant faunal feature.
Biotopes: *Urechis* communities*,* *Echiurus* communities

Biotic Group: Oligozoic [oz] - Zones that are devoid of macrofauna, larger fauna, and microbial mats, i.e., where no evidence of multicellular life can be detected when a sufficient area of the substrate is sampled to deliver sub-millimeter resolution, and where microbial communities are not visible to the naked eye. Meiofauna, however, may be present. It is inappropriate to identify this biotope with sampling methods that are not capable of sub-millimeter resolution and cannot detect infauna that may reside below the surface in soft sediments. Sampling methods which can resolve this Biotic Group include retrieval of substrate followed by sieving with $\leq$ 0.5 mm mesh size and stereoscopic examination, and sediment profile imaging with “standard” cameras providing sub-millimeter resolution at the faceplate. This Biotic Group is found in areas of extremely high stress (*e.g.*, anoxic zones, highly toxic areas, high-energy cobble beaches) where conditions cannot support either multicellular life or microbial mats. Oxic areas of subtidal sands are generally sparsely colonized by multicellular organisms (*e.g.*, haustoriid amphipods, small polychaetes) and are not considered Oligozoic.
Biotopes: anoxic oligozoic areas, meiofaunal communities, bacterial communities

Class: Aquatic Bed [AB]

Subclass: Macroalgae

Macroalgae or “seaweeds” can be grouped in three large divisions or phyla: Chlorophyta (green algae); Rhodophyta (red algae); and Phaeophyta (brown algae). Biotopes that are defined by macroalgae often include a variety of coexisting algal species, and in many cases identifying these species can be difficult. The Biotic Group level of classification here is based on the “Littler functional-form model” for marine macroalgae, as described by Littler et al. (1983) and promoted by Lobban and Harrison (1997). The Littler functional form groups are the sheet group, filamentous group, coarsely branched group, thick leathery group, jointed calcareous group, and crustose group (see Glossary). Littler et al. (1983) discuss the morphological, metabolic, and ecological significance of each group, and point out that these groups are best considered as recognizable points along a continuum, rather than as discrete bins. Biotic Groups and biotopes defined by macroalgae generally also include a diversity of associated fauna, including many that consume macroalgae, *e.g.*, sea urchins, mollusks, etc.

Biotic Group: Attached ephemeral macroalgae [ae] - Areas characterized by sheetlike, filamentous, or coarsely branched attached upright red, brown, or green algal forms, generally thin-bodied and fast-growing, with large variations in biomass on seasonal or shorter time scales.
Biotopes: mixed ephemeral macroalgae, *Ulva* communities, *Enteromorpha* communities, *Agardhiella* communities, *Chaetomorpha* communities, *Chordaria* communities

Biotic Group: Rockweeds [rw] - Communities characterized by Fucales, including rockweeds and wracks. These upright, attached brown algae feature thick blades and branches, a leathery, rubbery texture, and are common in rocky intertidal areas. The biotope includes many associated organisms, *e.g.*, *Mytilus, Littorina.*
Biotopes: *Fucus* communities, *Ascophyllum* communities

Biotic Group: Leathery Red Macroalgae [lr] - Communities characterized by upright, attached red algae with thick blades and branches, with leathery, rubbery texture, common in low intertidal rocky areas. The biotope includes many associated organisms, *e.g.*, limpets.
Biotopes: *Chondrus* communities

Biotic Group: Kelp Forests [kf] - Communities characterized by kelps and associated organisms. These upright, attached brown algae have thick blades and branches, a leathery, rubbery texture, and are found in shallow rocky subtidal areas. The biotope includes a variety of associated organisms, *e.g.*, urchins, abalone, crustaceans.
Biotopes: mixed kelp communities, *Macrocystis* communities, *Laminaria* communities, *Alaria* communities

Biotic Group: Leathery Green Macroalgae [lg] - Communities dominated by upright, attached green algae with thick blades and branches, with a leathery, rubbery texture, together with associated organisms.
Biotopes: *Codium* communities

Biotic Group: Jointed Calcareous Algae [jc] - Communities where attached algae with an articulated, calcareous, upright morphology and stony texture form the primary habitat structure. When these areas occur as part of a coral reef setting they are categorized under the BCC Class Coral Reef, Subclass Calcareous Algae (see above).
Biotopes: *Corallina* communities*,* *Halimeda* communities

Biotic Group: Attached Crustose Algae [ac] - Communities dominated by algae with a prostate, encrusting morphology, attached to a non-algal hard substrate, *e.g.*, rock, cobbles. Crustose algae have a stony or tough texture and may be calcified or uncalcified, When these areas occur as part of a coral reef setting they are categorized under the BCC Class Coral Reef, Subclass Calcareous Algae (see above).
Biotopes: *Hildenbrandia* communities*,* *Phymatolithon* communities

Biotic Group: Rhodolith Beds [rd] - Communities where red crustose algae form biogenic substrate, creating a stable, three-dimensional habitat. The substrate is primarily formed by colonization and growth of these crustose algae. When these areas occur as part of a coral reef setting they are categorized under the BCC Class Coral Reef, Subclass Calcareous Algae (see above).
Biotopes: *Lithothamnion* communities*,* *Lithophyllum* communities

Biotic Group: Drift Ephemeral Algae [de] - Communities dominated by unattached ephemeral algae that are negatively buoyant and remain associated with an area due to some interaction with the substrate (*e.g.*, bottom friction in shallow water, interactions with bottom structure, etc) rather than moving entirely freely with water currents.
Biotopes: drift *Ulva* communities*,* drift mixed ephemeral algae

Biotic Group: Drift Algae [da] - Communities dominated by unattached, negatively-buoyant, non-ephemeral (or unidentifiable) algae that remain associated with an area due to some interaction with the substrate (*e.g.*, bottom friction in shallow water, interactions with bottom structure, etc) rather than moving entirely freely with water currents.
Biotopes: drift kelp communities*,* drift rockweeds

Subclass: Rooted Vascular

Biotic Group: *Cymodocea - Thalassia* Seagrass Bed [ct]
This biotope group occurs in tropical and warm-temperate estuarine waters. In the western Atlantic Ocean, it is found from Florida to Mexico along the

Gulf Coast of North America, throughout the Caribbean, and extends up the Atlantic coast of Florida as far north as the St. Johns River. In general, the biotopes occur at depths of 1-4 m in warm sea waters (salinity greater than 17 PSU), on a variety of substrate textures. These seagrasses are not capable of growing in freshwater and are not found in the oligohaline upper reaches of estuaries and lower reaches of tidal creeks, bayous and rivers. The large seagrass beds of Florida's Big Bend, Florida Bay and the Laguna Madre of south Texas support examples of this group.
Biotopes: *Cymodocea filiformis* Seagrass Bed, *Thalassia testudinum* Seagrass Bed

Biotic Group*: Halodule - Halophila* Seagrass Bed [hh]
This group occurs in tropical and warm-temperate estuarine waters. In the western Atlantic Ocean it is widespread in waters of Florida and Texas, North Carolina and present in lesser amounts in other states. About 80,000 hectares are dominated by *Halodule* in Core and Pamlico sounds in North Carolina. These seagrasses are not capable of growing in freshwater and are not found in the oligohaline upper reaches of estuaries and lower reaches of tidal creeks, bayous and rivers. However, *Halodule wrightii* tolerates exposure to the atmosphere at low tide and occurs in water <1 m deep. *Halophila engelmannii* dominates at greater depths, primarily in low wave energy situations, and typically occurs at depths of from 6-20 m. The large seagrass beds of Florida's Big Bend contain examples of this group.
Biotopes: *Halodule wrightii* Seagrass Bed, *Halophila engelmannii* Seagrass Bed

Biotic Group: *Ruppia* Seagrass Bed [rp]
This group occurs in tropical and temperate brackish estuarine waters. In the western Atlantic Ocean, this widely distributed group includes estuarine and marine beds of the Atlantic and Gulf coasts, from New England to Texas, including the West Indies and tropical Florida. *Ruppia maritima* is the only seagrass capable of growing in freshwater and is therefore often found in the oligohaline to mesohaline (i.e. brackish) upper reaches of estuaries and lower reaches of tidal creeks, bayous and rivers. Because it often behaves as an annual, the distribution and abundance of *Ruppia maritima* is often shifting both spatially and temporally. Other species characteristic of these brackish estuarine waters include species of *Zannichellia* and *Stuckenia*. Rarely, some salt tolerant species of otherwise freshwater genera may occur.
Biotopes: *Ruppia maritima* Tropical Seagrass Bed, *Ruppia maritima* Temperate Seagrass Bed

Biotic Group: *Zostera* Seagrass Bed [zs]
Temperate Eelsgrass beds.
Biotope: *Zostera marina* Segrass Bed

Biotic Group: *Phyllospadix* Seagrass Group [ps]

Seagrass beds dominated by *Phyllospadix* spp.
Biotope: *Phyllospadix (scouleri, torreyi)* Seagrass Bed

Subclass: Microbial Mat

Biotic Group: Microphytobenthos [mp] - Visible accumulations of benthic diatoms, cyanobacteria, unicellular algae and other groups forming a film, crust, or "felt" at the surface of the substrate.
Biotopes: diatom communities, cyanobacterial communities

Biotic Group: Bacterial Mat [bt] - Colonies of bacterial decomposers and other decay organisms that can range in appearance from delicate and filamentous to a dense mass that may blanket the sediment surface. Bacteria may also be seen covering organic matter such as macroalgae.
Biotopes: *Beggiatoa* mat communities

Biotic Group: Chemoautotrophic Bacteria [ca] - Colonies of chemoautotrophs in specialized environments, *e.g.*, deep sea vents.
Biotopes: *Thiobacillus* mat communities

Class: Emergent Wetland

Subclass: Coastal Salt Marsh

Biotic Group: Emergent High Salt Marsh [hm] – Salt marshes dominated by herbaceous emergent vegetation that are infrequently flooded by tides and are characterized by distinctive patterns of vegetation, *e.g.*, *Spartina patens*. Low shrubs may be present but are not dominant.
Biotopes: *Monanthochloe littoralis* Emergent Tidal High Salt Marsh, *Spartina patens - (Distichlis spicata)* Emergent Tidal High Salt Marsh, *Spartina spartinae* Emergent Tidal High Salt Marsh, *Schoenoplectus americanus* Emergent Tidal High Salt Marsh

Biotic Group: Emergent Low Salt Marsh [lm] – Salt marshes that are regularly flooded by tides so as to support characteristic halophytic vegetation, *e.g.*, *Spartina alterniflora*.
Biotopes: *Spartina alterniflora* Tidal Low Salt Marsh,
***Juncus roemerianus* Tidal Low Salt Marsh**

Biotic Group: Emergent Brackish Marsh [bm] – Marshes with mesohaline salinity levels between 0.5 PSU and 18 PSU.
Biotopes:

***Amaranthus cannabinus* Tidal Brackish Marsh, *Cladium mariscus ssp. jamaicense* Tidal Brackish Marsh, *Sagittaria subulata - Limosella australis* Tidal Brackish Marsh, *Schoenoplectus pungens* Tidal Brackish Marsh, *Spartina alterniflora - Schoenoplectus robustus - Amaranthus cannabinus* Tidal Brackish Marsh, *Spartina cynosuroides* Tidal Brackish Marsh, *Typha (angustifolia, domingensis)* Tidal Brackish Marsh**

Class: Scrub-Shrub Wetland

Subclass: Coastal Salt Marsh

Biotic Group: Scrub-Shrub High Salt Marsh [sh] – Salt marshes dominated by halophytic shrubs or immature trees less than 6 m that are infrequently flooded by tides.
Biotope: *Baccharis halimifolia - Iva frutescens* Tidal Shrubland

Biotic Group: Scrub-Shrub Tidal Flat and Panne [fp]
Biotopes: *Batis maritima* Tidal Dwarf-Shrub High Salt Marsh, *Borrichia frutescens* Tidal Shrub-Scrub High Salt Marsh, *Sarcocornia pacifica - (Distichlis spicata, Salicornia spp.)* Tidal Shrub-Scrub High Salt Marsh, *Sarcocornia pacifica - (Distichlis spicata, Spartina alterniflora*) Tidal Dwarf-Shrub High Salt Marsh

Subclass: Mangrove

Biotic Group: Scrub-Shrub Mangrove [dm]: Dwarf or short mangroves and associates generally less than 6 m.
Biotopes:
***Rhizophora mangle* Tidal Mangrove Shrubland**

Class: Forested Wetland

Subclass: Mangrove

Biotic Groups: Forested Mangrove [fm]: Mangroves and associates taller than 6 m.
Biotopes: *Avicennia germinans* Tidal Mangrove Forest, *Conocarpus erectus* Tidal Mangrove Forest, *Rhizophora mangle* Tidal Mangrove Forest

5. The Sub-Benthic Component (SBC)

The specifics of this component are currently being further developed by the Mapping Partnership for Coastal Soils and Sediment (www.mapcoast.org). The following text provides a general description of those elements considered important for characterizing marine and estuarine substrates.

The Sub-Benthic Component (SBC) describes the structure and function of marine and estuarine substrate and sub-benthic habitats. This component considers aspects of the sub-benthic zone (i.e., soil and/or sediment) in profile to provide information with depth below the substrate surface. The SBC is designed to be flexible. Depending on the goals and resources of the mapping and classification project, any or all portions of the SBC may be characterized. However, supporting materials can and should be used to describe the choices made in collecting, processing, and analyzing data.

The upper 15 cm of the SBC layer provides detailed information, beyond that described in the SGC, regarding the texture (i.e., particle or grain size distribution), composition, infauna, and other characteristics. This layer can be sampled using remote sensing equipment (*e.g.*, acoustic sensors, video and/or still imagery) and grab and/or core samples. Complete classification of this layer may require use of multiple tools and sampling scales.

The area below (sub-benthic) the upper 15 cm of substrate is classified using traditional geologic or pedologic (soil) systems. This layer is usually described by examining undisturbed core samples (*e.g.*, vibracore, boreholes). Characteristics including particle size, color, chemical composition, and biogenic features such as shell deposits, infauna, or microbial constituents are used to describe this layer.

Users of the classification system choose the level of detail for their purposes depending on mapping scale and on the appropriate application of collected data. For example, a shallow water coastal lagoon mapped for a variety of needs such as aquaculture, dredging, and eelgrass restoration may require detailed upper substrate and sub-benthic data to determine important characteristics such as acid sulfate weathering of the dredge material or location of suitable bottom types for aquaculture. The SBC will also be needed in deep-water habitats for paleooceanographic studies and for specific engineering purposes including construction, placement of wind turbines, and oil exploration.

6. The Geoform Component

The Geoform Component (GFC) describes the structure of the sea floor at multiple scales. The GFC addresses three aspects of the seafloor morphology: Physiographic Province, Geoform and Anthropogenic Geoform. The framework for the GFC adopts most of the structures described by Greene et al. (2007), but expands the options to include a larger number of coastal and nearshore features. Modifiers are available to further describe geoform features. While Geoforms and Anthropogenic Geoforms do nest within Physiographic Provinces, the GFC does not require that hierarchical relationships be specified. Users may choose to use Physiographic Provinces, Geoforms, or Anthropogenic Geoforms singly or in combination. GFC types listed in this document are considered “draft” and are subject to modification as the standard is applied over time. See Appendix F for a table of the GFC units and Chapter 8 for modifiers.

Physiographic Province

The Physiographic Province (akin to Greene’s Megahabitat) describes the major components of the seafloor geomorphology along the continuum from the spreading center to the coast. (e.g., fracture zone, abyssal plain, continental rise, continental shelf). These features can be defined with the use of bathymetric maps and satellite images (1:1,000,000 or greater).

Geoform

Geoforms are seafloor structures that range in size from 100’s of kilometers to less than a meter (e.g., delta, embayment, lagoon coral head, rock outcrop - Figures 11-14). A Geoform is equivalent in concept to a terrestrial landform (*e.g.*, mountain, butte, moraine, dune, etc.) and likewise varies in size from very large (*e.g.*, seamount, embayment) to very small (*e.g.*, tidepool, ripple). Geoforms shape the large scale seascape in repeatable and predictable ways by providing structure, channeling energy flows, regulating bioenergetics, and controlling transfer rates of energy, material and organisms. The morphology of these features controls such processes as water exchange rates and water turnover times, hydrologic and energy cycling, shelter and exposure to energy inputs and migration and spawning patterns. Special attention is given the identification and description of the geomorphology of Estuarine Systems, which in CMECS are grouped into four broad types based on the shape of the enclosing basin: Riverine, Lagoon, Embayment and Fjord. Additional description of these estuarine types can be found in Appendix G.

Large geoforms can be defined using geologic or geomorphic maps and bathymetric images of the seafloor at scales of 1:250,000 or less. Individual coral heads, tide pools and sand ripples can be identified through in situ observational data such as video and photographs. The Geoform departs from the Greene classification in two ways: below the Physiographic Province, scale or size is not a criterion for differentiating units; and the GFC does not include surface geology attributes such as hardbottom, softbottom, sand, gravel, and cobble as in Greene et al. (2007) because these attributes are included in the SGC of CMECS III.

Figure 11. Examples of various sized Channel Geoforms. Hamlin Sound, South Carolina.

Figure 12. Example of Geoform: Inlet. Fripp Inlet, South Carolina.

Figure 13. Example of Geoform: Flat. Lower Laguna Madre, Texas.

Figure 14. Pacific coast tide pool; One of the smallest features to be found in the geoform category (Courtesy U.S. Fish and Wildlife Service).

Anthropogenic Geoforms

In many coastal and deep oceans artificial structures are a significant part of the environment. The continually or intermittently submerged portions of features such as piers, breakwaters, bulkheads, berms, drilling rigs and artificial reefs provide attachment surfaces for plants and sessile animals and attract vagile fauna. They can also provide shelter from predators and from prevailing current, and can support niche communities that increase overall biodiversity. However, these structures can also have negative effects such as altering natural hydrodynamic patterns, interfering with animal movement, and increasing contaminant loading into nearshore areas and thus are often of interest to resource managers. Appendix F lists some of the more common anthropogenic geoforms. Included in this list are features that are the result of human activity such as scars and trawl marks. Since these features vary greatly in size, the types in this category can be applied at any scale (Figure 15).

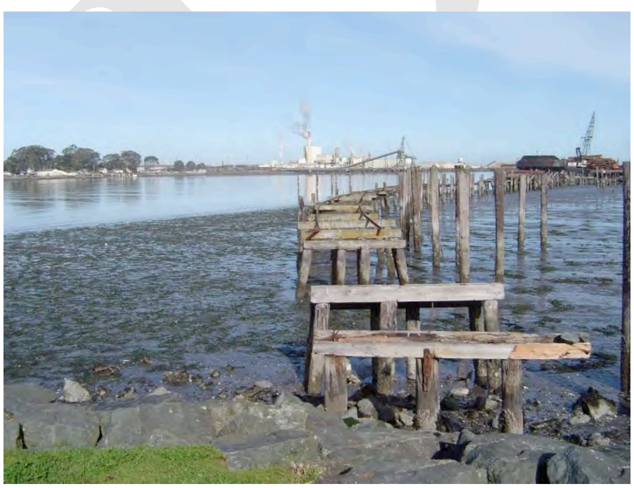


Figure 15. Example of an anthropogenic Geoform structure: Pilings, Abandoned rail trestle, Humboldt Bay, California.

7. The Water Column Component

The Water Column Component (WCC) describes the structures, patterns, physical properties, processes and associated biology of the water column. While highly variable spatially and temporally, the water column is composed of repeating hydromorphic structures, physical properties and processes that strongly influence the distribution and condition of biota. Because of its dynamic and vertical nature, the water column can be a challenge to map. In many cases it will be preferable to map individual vertical zones of the WCC as separate GIS layers.

The WCC framework is formed using a set of standard attributes known as classifiers that are necessary to classify one unique unit from another. Classifiers identified for the WCC include: water column depth zones, water column structure, hydroform, salinity, temperature, biotic group and biotope. Water Column Depth provides a standard list of vertical depth zones of the water column. Water Column Structure provides an ecological zonation of the water column determined by water density differences caused by clines in temperature or salinity. Hydroforms describe hydrographic features at different scales. Biotic Group represents groups of biotopes defined by one or more dominant organisms such as phytoplankton, zooplankton, vegetation mats etc. Biotopes of the water column are repeating dominant floating or suspended taxa.

In addition to the classifiers, the WCC has a set of assessment parameters that can be used to help characterize the condition of the WCC unit. The assessment parameters are optional and applied much like modifiers but are unique to the WCC. These include oxygen, turbidity, photic quality and productivity. Assessment parameters can be used alone or in combination to assess the condition but classifiers must be applied to describe the structure and composition of the water column. The System is the same as that of the other components and should always be used to put the water column types into the same context.

The framework of the WCC is in the process of being reviewed and refined. Additional work is ongoing to develop rules for combining classifiers and to develop the catalog of water column units.

WCC Classifiers

Water Column Depth Zones

The water column is divided into several vertical zones based on water depth.

Zone	Depth (m)
Sea Surface [Surf]	0
Epipelagic [EpiP]	> 0-200
Mesopelagic [MsoP]	200-1000

Bathylpelagic [BtyP]	1000-4000
Abyssalpelagic [AbyP]	3500-6000
Hadalpelagic [HadP]	>6000

Water Column Structure

The water column can be subdivided into an upper mixed layer and a bottom layer, separated by a pycnocline. This is often ecologically relevant in terms of habitat, although two layers are not always present. An important functional distinction is created by temperature or salinity differences in the upper and bottom layers of the water column. When present, the upper layer is separated from the lower layer by a difference in density, which results in a barrier to mixing between the layers. The two water layers define separate mixing zones and energy regimes, create barriers to movement of materials and fauna, and create an interface where intense biological processes may occur. Stratified water masses are highly stable, and waters may maintain stratification for many months. Stratification is broken down usually on a seasonal or annual basis by wind or current energy input. In the case of thermally stratified water columns, breakdown is usually initiated by homogenation of the densities of the two vertically separated water masses by a convergence in their temperatures. When mapping the water column, it is advisable that one use the water column structure to develop separate GIS map layers.

Upper water column layer - In a two-layer water column, the area above the sharp density gradient (pycnocline) which includes the air-water interface. Pycnoclines are generally formed by salinity or temperature differences between the upper and lower water layers and create effective barriers to transport across layers. The water layers remain largely distinct; in some circumstances, current regimes may flow in opposite directions.

Pycnocline - The layer of rapid density transition between the upper and bottom layers.

Bottom water column layer- In a two-layer water column, the waters below the pycnocline or mixed layer composes the bottom water column layer.

Benthic boundary layer - A thin water layer just above the bottom that is strongly influenced by the benthos and is distinct from the overlying waters. It is often characterized by sharp reductions in current speeds, a nephelitic turbidity layer and high rates of diffusive interaction with biogeochemical components in the sediments. This layer is often strongly associated with small benthic or demersal organisms.

Salinity

Salinity is grouped into categories in units of PSU (practical salinity units, nearly equivalent to ppt, parts per thousand) following Cowardin et al. (1979), Dethier (1990) and with ranges slightly modified from Howes (1994, 2002):

Salinity Category	Salinity Range
Fresh	0 PSU
Oligohaline	>0-5 PSU

Mesohaline	5-18 PSU
Polyhaline	18-30 PSU
Euhaline	30-40 PSU
Hyperhaline	>40 PSU

An underlying benthic area subjected to overlying waters of a particular salinity regime will be designated according to the category of the overlying water. Thus characterizing the benthos will require measurement of overlying water characteristics. This is particularly important close to shore or in estuaries as the tendency of the coastal water column to stratify will often result in water mass characteristics at the surface that are not the same as the bottom water layer that influences the benthos.

Temperature

Temperature categories are established in intervals of 10°C; these intervals are sufficient in range and resolution to provide meaningful differences yet yield a parsimonious number of categories. Temperature categories are based on the BCMEC classification for Canada (Howes 1994, 2002, Zacharias et al. 1998), modified to add the higher temperature ranges typical of the subtropics and tropics. The caveat that differential surface and bottom characteristics occur in the water column holds for temperature as well as salinity. Categories for water mass temperature are established as follows:

Temperature Category	Degrees
Frozen [Froz]	≤ 0° C with surface ice
Superchilled [SChd]	≤ 0° C without ice
Cold [Cold]	0-10° C
Temperate [Temp]	10-20° C
Warm [Warm]	20-30° C
Hot [Hotw]	>30° C

Hydroform

The hydroform features of marine systems range from large physical features or boundaries created by water masses of 10,000 m^2 or larger that are generally (but not exclusively) associated with the deeper waters of the Neritic and Oceanic Systems to small hydrographic features generally associated with Estuarine and Nearshore Systems. Examples include major ocean currents (such as the Gulf Stream), large coastal fronts, the great ocean gyres, and upwellings. Hydroforms represent hydrological environments that define patterns in the composition and dynamics of both the physical worlds contained within them and the biota associated with their divisions. While dynamic in nature, hydroforms shape the large scale seascape in repeatable and predictable ways by providing structure, channeling energy flows, regulating bioenergetics, and controlling transfer rates of energy, material and organisms. See Appendix E for specific Hydroforms.

Biotic Group

Assemblages of species identified by dominant organism(s) or taxa.

Phytoplankton Bloom– A high concentration of phytoplankton in an area, caused by increased reproduction (Garrison, 2005). Blooms reflect populations above the normal level for an area.

Floating microbial mat - Microbial accumulations that occasionally form on the water surface as a film or scum.

Floating detached vegetation mat - Accumulations of detached, dead, floating vascular plants. In the marine environment these can often consist of rafts of detached leaves and stems from either terrestrial or aquatic vegetation. As these rafts either sink or wash up on shore they become either detritus or wrack respectively.

Drift macroalgae - Macroalgal accumulations suspended in the water column.

Floating macroalgae - Macroalgal accumulations at the surface. Often these are formed of algae specifically adapted for this environment such as *Sargassum*.

Zooplankton - Concentrations of zooplankton such as crustaceans and copepods that form in response to specific light, current, turbulence, and abundance conditions.

Jellyfish aggregations - Schools or large numbers of jellyfish within the water column.

Biotope

Biotopes of the Water Column are floating or suspended aggregations of biota and are defined by the dominant taxa (usually genera or species). Biotope patterns and distributions are determined by and associated with water column structure and dynamics. Motile, free-swimming or vagile faunal species are not included in the biotope. Biotopes for the Water Column Component will be determined as the standard continues to develop.

WCC Assessment Parameters

Oxygen

Oxygen concentration is often an important water column modifier. Oxygen is critical to aerobic organisms and to aerobic processes, such as chemical oxidation and microbial respiration. The oxygen regime modifier is determined according to the following ranges, noting that oxygen saturation varies with temperature and pressure.

Oxygen Regime	Oxygen Concentration
Anoxic [Anox]	0 - 0.1 mg/L
Severely Hypoxic [SHpx]	0.1 - 2.0 mg/L
Hypoxic [Hypx]	2.0 - 4 mg/L
Oxic [Oxic]	4-10 mg/L
Oxygen saturated [OxSt]	10-12 mg/L
Oxygen supersaturated [OxSS]	>12 mg/L

Turbidity

Turbidity is important for organisms that hunt for prey or escape using visual cues, and of course for photosynthetic organisms. Categories for the turbidity modifier have not previously been established in a coastal-marine classification system. The proposed categories for turbidity are based on simple secchi depth readings:

Turbidity Category	Secchi Depth Reading
Extremely Turbid [ExTr]	<1 m
Highly Turbid [HiTr]	1-2 m
Moderately Turbid [MdTr]	2-5 m
Clear [Cler]	5-20 m
Extremely Clear [XClr]	>20 m

Turbidity Type and Turbidity Provenance

An important qualitative characteristic of turbidity is the provenance of the attenuating substance - whether the reduced water clarity is derived from chlorophyll pigments (i.e. phytoplankton blooms), from color due to dissolved substances in the water (gelbstoffe, tannins), from mineral imported terrigenous sediments or from carbonate particulates in resuspension. This qualitative assessment can be used in addition to a qualitative or quantitative evaluation of the degree of turbidity in the water column.

Turbidity Type

Chlorophyll [Chlr] **-** attenuation produced by chlorophyll a, b, c or d as constituents of live phytoplankton in the water column

Mineral particulates [Mnrl] **-** attenuation produced by suspended inorganic sediments derived from soil and rock weathering

Carbonate particulates [Carb] **-** attenuation produced by suspended precipitated $CaCO_3$ in the water column, generally creating an opaque “milky” appearance

Colloidal precipitates [Coll] **-** dispersed particulates which precipitate out of the dispersion medium (water) to form aggregations such as marine snow

Dissolved color [DCol] **-** substances dissolved in water that have color and absorb light within a specific band of wavelengths

Detritus [Detr] **-** attenuation due to larger particles of organic detritus in suspension

Mixed [MxTr] **-** attenuation due to a variety of the above sources and substances

Turbidity Provenance

Autochthonous [Auto] **-** (*e.g.* bloom) generated in situ by biogenic processes

Allochthonous [Allo] **-** originating outside of the system and transported into the system

Resuspended [RSsp] **-** deposited materials mixed into the water column by currents (*e.g.* bottom sediments)

Precipitated [Prcp] **-** solutes such as $CaCO_3$ that precipitate out of solution

Terrigenous origin [Terr] **-** materials, water or energy in a water body in land drainage

Marine origin [Mari] **-** materials, water or energy originating in the ocean

Photic Quality

Photic quality is a highly variable parameter. In many Nearshore cases, light penetrates deeply, and the photic zone extends to the bottom of the water column; in other cases, almost the entire water column is dark. All Systems are aphotic for at least part of every day, during nighttime. Degree of exposure of a particular place to light depends on the depth, sun angle, time of year, and other factors. Moreover, the depth of the shift from photic to aphotic occurs at different points in the water column, depending on the ecosystem, watershed, the amount of turbidity in the water, etc. The important functional distinctions of the photic regime are between the parts of the water column within which plants can and cannot photosynthesize, and between the parts within which animals can and cannot feed and defend visually with ambient light.

Vertical zones are relative to the penetration of light: photic and aphotic, for both water column and benthic components:

> *Photic* [Phot] **-** that region of the water column where ambient light is > 2% of surface light and photosynthesizing organisms can exist. This is ecologically significant as the photosynthetic compensation point, where respiration equals autotrophic production
>
> *Dysphotic* [Dysp] **-** that part of the water column below the compensation depth, that receives less than 2% of the surface light, and where plants and algae cannot achieve

positive photosynthetic production, but where some ambient light does penetrate such that animals can make use of visual cues based on reduced levels of ambient light.

Aphotic [Apho] **-** that part of the water column where no ambient light penetrates, no photosynthesis occurs, and animals cannot make use of visual cues based on even reduced levels of ambient light. Typically this zone lies below 500 - 1000 m of depth.

Seasonally photic - **regularly varies between photic and dysphotic/aphotic**

Productivity

Productivity is a general categorization of the abundance of dissolved macronutrients (DIN and DIP) and level of primary productivity of a unit. In broad terms, the productivity gives an indication of the health of the system via the balance of production and consumption. Productivity is measured by chlorophyll concentration in water columns and by total biomass in macroalgal and rooted vascular plant communities. For water column phytoplankton communities, the modifier categories are:

Productivity - Phytoplankton	**Chlorophyll Level**
Oligotrophic [Olig]	< 5 µg/L chlorophyll a
Mesotrophic [Meso]	5-50 µg/L chlorophyll a
Eutrophic [Eutr]	> 50 µg/L chlorophyll a

The productivity categories were derived, with modification, from the NOAA Estuarine Eutrophication Survey (NOAA 1997).

8. Standard Attributes

Standard attributes are physico-chemical, physical, spatial, geological, biological, anthropogenic, and biogeographic variables with defined categorical values that are used to classify or further describe CMECS types. Standard attributes fall into two general categories, classifiers and modifiers.

Classifiers

These standard attributes that are necessary and required to define a type and distinguish one type in the classification from another. The thresholds and ranges of these attributes determine the conceptual boundaries of each type. For example, salinity is a classifier for the System level. A salinity value of >30 PSU separates the truly marine systems from the Estuarine and Freshwater Influenced Systems. A user must determine values of classifiers in order to fit a given type into the classification.

Modifiers

These standard attributes that can be applied when additional information is needed to further characterize an identified type for individual applications. Modifiers provide additional environmental, structural, or biotic information about the habitat type that is useful for description and application, but are not required for classification according to the CMECS III schema.

Some standard attributes may be used as classifiers in one component of the classification but can also be used as modifiers in another component of the classification. These designations are provided in italics below.

Enclosure

Classifier for System
Modifier for GFC

Enclosure represents the degree of isolation of a water body from other waters due to enclosure by a land mass. In estuaries, enclosure determines the degree of exchange of water, materials, energy and biota between the estuary and the sea. More enclosed water bodies have longer water residence times, can tend to be more evaporative and hypersaline, and can more readily trap and retain materials within them.

Enclosure	Angular Gap (Degree)
Unenclosed [UnEn]	> 150° angular gap from landward end of water body to seaward opening. No confining land masses (*e.g.*, islands) within or just outside water body.
Partially enclosed [PrEn]	90° - 150° angular gap from landward end of water body to seaward opening.
Significantly enclosed [SgEn]	45° - 90° angular gap from landward end of water body to seaward opening.
Very enclosed [VyEn]	10° - 45° angular gap from landward end of water body to seaward opening.
Enclosed [Encl]	Essentially separated from the ocean. Waters that are completely surrounded by land or with a narrow channel connection to the sea. Includes perched estuaries and lagoonal estuaries.
Intermittent [Intm]	Class of water bodies that regularly close due to low flow, opening seasonally during high flow. Also called ICOLL (Intermittently Closed and Open Lake or Lagoon)

Position Relative to Shelf Break

Classifier for System

This classifier indicates the position of an area of the ocean relative to the edge of the Continental Shelf. There are two positions considered here:

Seaward of the shelf break [Seaw] - Where the continental platform begins to steepen toward the continental slope, defines the Oceanic System; and

Landward of the shelf break [Lndw]- Defines the outer limit Neritic System.

The depth at which the Shelf Break occurs ranges from 100 to 200 m and generally averages approximately 200 m.

Benthic Depth Zones

Modifier for SGC, BCC and GFC

The depths of these zones vary depending on regional geology and turbidity. It is often useful to describe a specific depth or range of depths for the bottom. The CMECS depth zones represent the major divisions in a gradient from land to the deep ocean bottom. They are generally based on the zones in which surf or ocean swell influences bottom communities, the lower limits of vegetation such as kelp, overall photic availability and temperature. The types within this category are drawn or adapted from Greene *et al (2008)*, and Connor. This category is intended for use with the Benthic Cover and Geoform components as Water Column Depth Zone is part of the Water Column framework. The following definitions are intended as guidance for adaptation of depth ranges to regional environmental conditions:

littoral: all areas that are episodically exposed to air; intertidal.
sublittoral: all areas permanently covered by water, including:
- infralittoral: subtidal areas within the photic zone, often characterized by macroalgae or rooted vascular plants.
- circalittoral: subtidal areas below the photic zone, generally characterized by animal communities (although very sparse algae may be present).

Benthic Depth Zone	Approximate Depth Range (meters)
Littoral [Litt]	**Intertidal**
Shallow Infralittoral [SInf]	**0 - 5**
Deep Infralittoral [DInf]	**5 - 30**
Circalittoral [Circ]	**30 - 200**
Mesobenthic [MsoB]	**200-1000**
Bathybenthic [BtyB]	**1000-3500**
Abyssalbenthic [AbyB]	**3500-6000**
Hadalbenthic [HadB]	**>6000**

Percent Cover Range

Classifier for Class and Subclass
Modifier for BCC

This standard attribute is used to describe the density of substrate components.

To classify a unit to the Class and Subclass level of the BCC, a users need to know the relative percent cover of each of the components of the substrate (see substrate composition above). The degree of substrate cover for each benthic feature is assessed using the following ranges (after the SCHEME classification of Madley et al. 2003).

These categories can also be used as a modifier to describe the density of vegetation such as seagrasses or other substrate components.

Percent Cover Category	Percent Cover Range
Bare [Bare]	< 1% cover
Sparse [Sprs]	1-10% cover
Moderately Sparse [MdSp]	10- 25% cover
Moderate [Modt]	25-75 % cover
Dense [Dens]	75%-90% cover
Complete [Cmpl]	90-100% cover

Energy Type

Modifier for GFC and WCC

To describe energy type, CMECS follows a simplification of the concept introduced by Dethier (1990), also employed in several subsequent classifications (Holthus and Maragos 1995, Howes 1994, 2002, Schoch 1999, Allee et al. 2000). The work of Schoch (1999) provides the basis for a detailed near-shore classification of energy intensity and type on land-sea margins. This scheme utilizes a very simple energy classification related to the force of water movement, whether tidal, wave or current. Energy determines the kinds of animals and flora that can maintain attachment or position in a particular habitat. Energy level also determines the substrate type by suspending, transporting and sorting fractions of substrate particulates of specific grain sizes. Energy can shape the bed forms (sand waves, sand ripples) and erode or accrete geoforms. Highly impacted areas are typified by the presence of erosive features, such as beach scarps or bare rock substrates.

The terminology of "degree of exposure" common in many other classifications is not used in CMECS in favor of the more accurate term "energy." Exposure is a subjective term that includes qualification of both the direction of the feature relative to hydrodynamic energetics and the energy of the system at a given point in time. An exposed and open coast may in fact be very quiescent depending on the season or direction facing. "Energy," along with a quantitative scale, is a more accurate indicator of the actual force with which a particular coastal or marine feature is impacted.

The energy modifier applies to all three components of the classification (benthic, water column and geoform). Within the intertidal and subtidal benthic zones, energy acts to shape the geoforms. Within the water column, the energy is related to current speeds (in knots), wave intensity and tidal motions. The concept is modified from Dethier (1990) and Zacharias et al. (1998) with type categories as follows:

Energy Type	Description
Wind [Wind]	coherent directional motion of the atmosphere
Current [Curr]	coherent directional motion of the water
Surface wave [SWav]	vertical and transverse oscillating surface water motion due to wind or seismic energy
Internal wave [IWav]	vertical and transverse oscillating water motion below the surface due to seismic energy or pressure differential
Tide [Tide]	periodic horizontally oscillating water motion

Energy Intensity

Potential Classifier for Group
Modifier for SGC, BCC, GFC, and WCC

Energy Intensity is captured as a "Regime" and is classified according to the following scale:

Energy Regime	Description
Very low energy [VLEn]	area experiences little wave or current motion under most conditions
Low energy [LoEn]	area typically experiences very weak currents (0-1 knots) and only gentle wave action.
Moderate energy [MoEn]	area regularly experiences significant wind waves or moderate tidal currents (1-3 knots)
High energy [HiEn]	area regularly experiences strong currents (> 3 knots), large oceanic swells, or breaking waves

Energy Direction

Modifier for WCC

Energy can also be classified according to its principal direction of travel or influence. In the case of tidal energy, this is generally an oscillation between onshore and offshore motions. In the case of currents and waves, the energy is usually directional. The following energy direction categories are used:

Energy Direction	Description
Upward [Upwd]	ascending and perpendicular to the sea surface or bottom
Downward [Dnwd]	descending and perpendicular to the sea surface or bottom
Horizontal [Hriz]	parallel to the sea surface or bottom
Baroclinic [Baro]	motion along lines of equal pressure within the water column
Seaward [Sewd]	on land, water currents following topographic gradient toward the sea
Circular [Crcl]	motion in a closed circular form
Mixed [Mixd]	combination of more than one of above directions

Tide Range

Modifier for SGC, GFC and BCC

The tide range modifier refers to the difference between mean high tide and mean low tide at the coast. While the intertidal Subsystem is defined by the area submerged by tide between the extreme high and low tides, the mean range gives a more consistent idea of the energy and amplitude of the average tide. Tide range is categorized as:

Tide Category	Tidal Range
Microtidal [MiTd]	<0.1 m
Small tide range [SmTd]	0.1- 1 m
Moderate tide range [MoTd]	1-5 m
Large tide range [LgTd]	>5 m

Primary Water Source

Modifier for BCC, WCC, and GFC

The primary water source modifier refers to the provenance of water flowing through or into a formation. This can range from freshwater inputs from river watersheds or sloughs to local exchanges through tidal passes. The categories are as follows:

Primary Water Source	Provenance
Watershed [Wshd]	for flowing freshwater, the upstream watershed
Local estuary exchange [LoEs]	tidal exchange that is primarily estuarine water
Local ocean exchange [LoOc]	tidal exchange that is primarily marine water
River [Rivr]	tidal exchange or plume flow that is primarily river water
Estuary [Estu]	plume flow that is from the estuary
Marine [Mrin]	unidirectional flow that is primarily marine

Profile

Modifier for SGC, BCC and GFC

Profile refers to the elevation of a feature relative to the surrounding level of the water or bed:

Profile	Relative Height
None [NoPr]	0
Low [LoPr]	0-2 m
Medium [MdPr]	2-5 m
High [HiPr]	>5 m

Slope

Modifier for SGC, BCC and GFC

Slope refers to the angle of the substrate at a scale appropriate for the feature being described; Greene et al.'s (1999) geological classification is followed here to characterize slope as:

Slope	Vertical Angle
Flat [Flat]	0-5°
Sloping [Slpg]	5-30°
Steeply sloping [SSlp]	30-45°
Vertical [Vert]	45-90°
Overhang [Ohng]	>90°

Anthropogenic Impact

Modifier for SGC, BCC, GFC, and WCC

Developed **-** coastal or marine areas that have been modified by construction of durable and persistent human construction (*e.g.*, artificial reef, pier, seawall, marina, residence, drilling platform).

Impounded/Diverted **[Impd]** – areas where artificial construction impedes, redirects or retains hydrological flow by building or placing barriers such as levees or dams, either to retain water or to prevent inundation (*e.g.*, dam, levee, dike, berm, seawall, pier).

Dredged area/Channel **[Drdg] -** Landscape that is mechanically altered by the removal of sediments or other materials (*e.g.* shell), for deepening or widening channels (*e.g.* for navigation or alteration to hydrology).

Filled **[Flld]** - areas where materials such as sand or shell have been placed on or in an area of coast or a water body.

Contaminated **[Cont]** - areas affected by past or present anthropogenic discharge of unnatural compounds such as nutrients, sewage, metals, pesticides, or other materials to waters or substrates, resulting in concentrations significantly higher than those attributable to natural loading.

Rugosity

Modifier for SGC, BCC, and GFC

Definition adapted from Greene et al., 2008. Rugosity is a function of the amount of surface area for a given planar area of the seafloor and is quantified through gridded X, Y, and Z data. The following table illustrates the five rugosity types and their associated numeric values.

Rugosity Types	Rugosity Range
Very Low [VLoR]	1.0 – 1.25
Low [LowR]	1.25 – 1.50
Moderate [ModR]	1.50 – 1.75
High [HghR]	1.75 – 2.00
Very High [VHiR]	> 2.00

Temporal Persistence

Modifier for SGC, BCC, GFC, and WCC

The temporal persistence descriptor describes the permanency or variability of a hydromorphic, geomorphic, or biological feature. Though qualitative and relative, it is useful is distinguishing between features that are similar in morphology but are temporally diverse in terms of stability. An example is a mud shoal versus a mudbank. The former tends to be moved by changing currents or storms, while the latter is more stable and persistent. Classes are:

Persistence
Stochastic [Stoc]
Hours [Hors]
Days [Days]
Weeks [Weks]
Months [Mnts]
Seasons [Seas]
Years [Yers]
Inter-annual [IntA]
Decades [Decs]
Centuries [Cent]

Ecological Region

Ecological regions or "Ecoregions" are defined as very large areas of the coasts and oceans that are relatively homogeneous with regard to physical and biological variables. Ecoregions reflect ecological boundaries determined by climate (temperate, tropical, polar), physical structure (major currents or ocean basins), and biological associations (isolation or endemism). Marine ecoregions are defined by large seas, currents and regions of coherent sea surface temperature or ice cover. Spalding et al. (2007) delineate marine ecoregions of the world based on extensive literature review and CMECS adopts these units (Appendix J).

9. Applying CMECS in Mapping and Classification

The five components of CMECS represent a way of organizing information to describe different aspects of the coastal and marine environment. The units within each component are the various elements that make up the seascape, and these units can be re-arranged in a variety of ways to categorize different types of aquatic habitat. In one example, habitats may be most usefully characterized under both the SGC and the BCC through the concept of benthic “cover” - a characterization of the seafloor as what one would ‘see’ if overhead, looking directly down with the unaided eye. The CMECS framework allows classification and mapping of this (and other) concepts because information from several components can be combined in different ways, depending on project goals, and because the components share a common coding system (see Chapter 10). This structure also allows the CMECS framework to be compatible with a variety of sampling methods and observational tools.

CMECS descriptor units form the raw material for maps that may be derived from one or more components. This is a departure from many traditional classification systems that are designed for mapping using a specific technology and confine seascape elements into a flat structure based on what that technology can observe. Mappers have a number of options for compiling spatial data using CMECS units. They may draw from various components to assemble a spatial data set (map) or they may work entirely within a component and develop separate maps for each one. The approach taken for any given project would be driven by the information needs of the effort, source data type, project logistical constraints, and perhaps most importantly, spatial exclusivity between those units being integrated in the map.

In this design the CMECS component structure forms an organizing bridge between spatial map data on the one hand and ecological assessment on the other. This frees the standard from the limitations of any specific technology. It also allows maps developed according to other classification systems to be incorporated into the CMECS structure. The work can be compliant with the CMECS standard as long as the terminology used and any hierarchical relationships are consistent with the CMECS components and units.

Figure 16 illustrates conceptually how a habitat map employing elements from various CMECS components could be assembled into a single “flat” spatial data set. In this case the technology might be an aerial optical instrument. Those units of CMECS that can be detected using this technology, and are of concern for this mapping project are included in the map. The arrows indicate how the CMECS units form a menu of mapping elements for this map. The arrows also indicate how spatial data that the map provides will populate the CMECS database and be available to other users. This approach may be preferred where the units are generally spatially exclusive and where one technology is being employed.

An example of how this might look is shown below in Figure 17. In this case, the focus of the project was the distribution of seagrass and macroalgae as well as areas available for new colonization (shallow unconsolidated bottom).

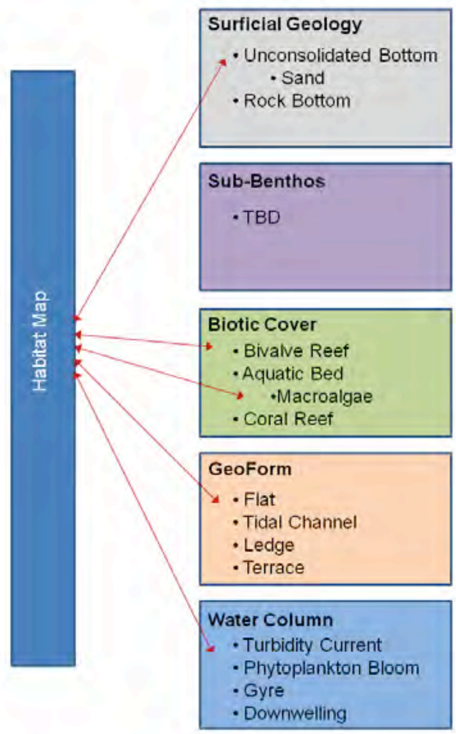


Figure 16. Example of the relationship among CMECS units from various components and an integrated "flat" map.

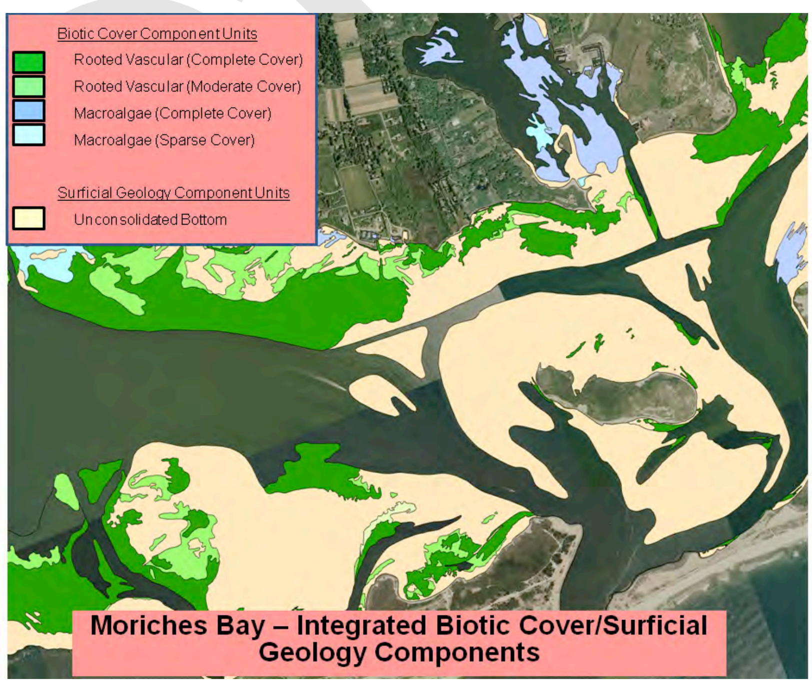


Figure 17. Moriches Bay, New York integrated component map.

Figure 18 below illustrates the approach where each component is captured in an independent spatial data set. Using an optical image source as before separate data are compiled for each component. Despite being topologically separate data, they can be integrated through various GIS tools such as the Geodatabase data structure. This approach may be preferable where wall-to-wall information is desired for each component and there is minimal spatial exclusivity between units, that is, landscape units (polygons) tend to overlap or where more than one technology is being used.

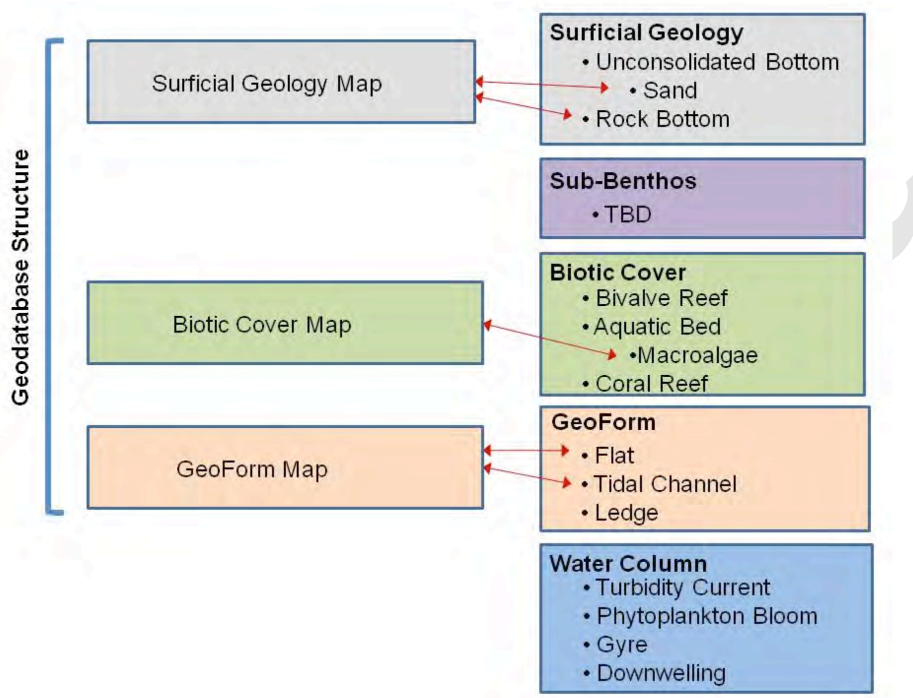
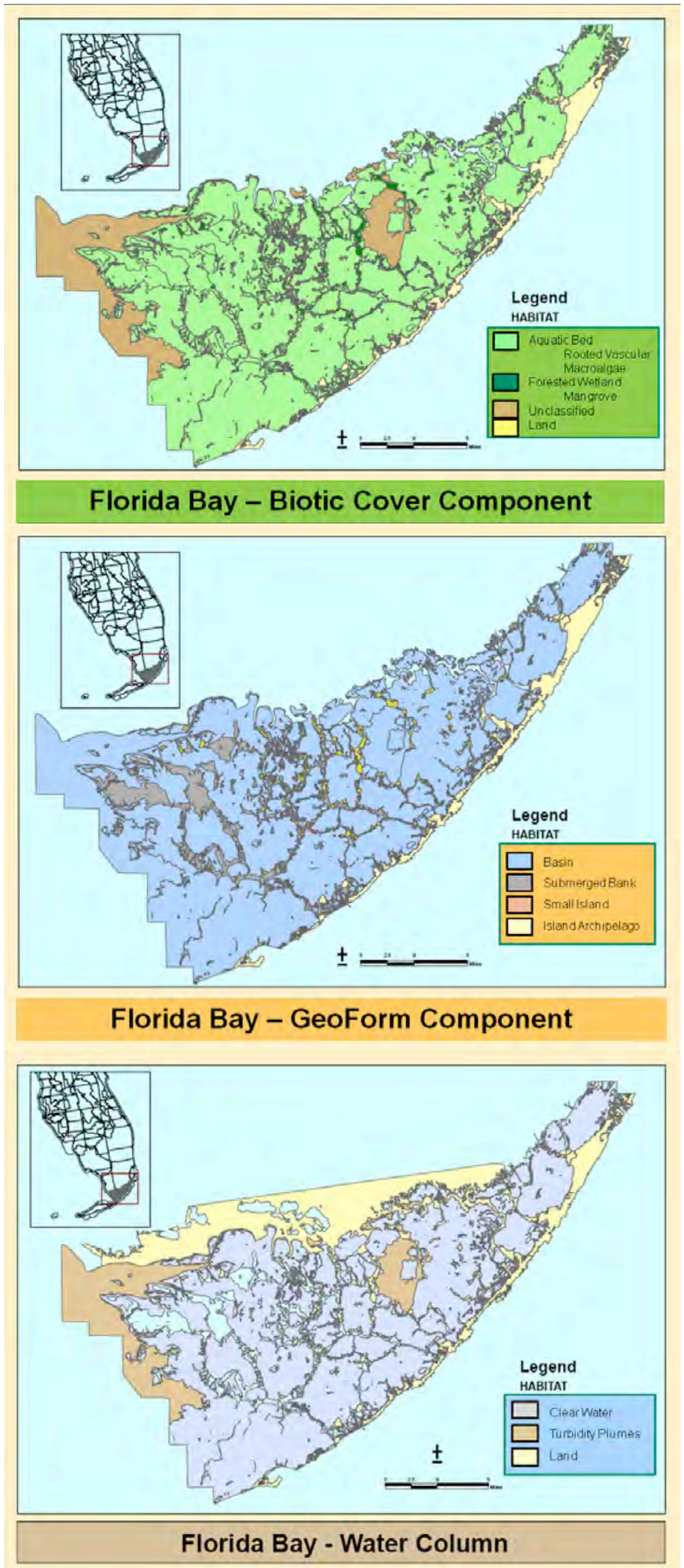


Figure 18. Example of the relationships among CMECS units from various components and three component-based maps. The Geodatabase data structure allows the individual maps to be integrated for analysis.

The map examples that follow (Figure 19) illustrate separate data sets for each component that could then be overlain and analyzed together in a GIS environment. Assembling a topologically complete map from the various components or a cohesive geodatabase will require rule sets and guidance for users. Such guidance for mapping will be produced in separate documents and will be free to evolve as technologies advance and data analysis needs change.



Figures 19. Independent component-based maps for Florida Bay, Florida.

10. Code Structure for CMECS

As discussed in Chapter 9 above, the five components of CMECS are intended to co-operate so as to describe the geological, chemical, physical, and biological associations that constitute "habitat." To bring these aspects of habitat together, CMECS uses a single code structure to incorporate any or all types of CMECS information into one code sentence that can be consistently applied. Code labels (e.g., abbreviations or acronyms) uniquely describe classification concepts, and so the code sentence is searchable. The code allows easy updating, so that new types of spatial data can be added to existing code sentences for older data at locations. The code sentence can also be taken apart, so that practitioners can synthesize new ways to analyze or map habitat. The code can be used to describe point locations or polygons, and can be used for other applications in classification as well.

The CMECS "common code" begins with System and Subsystem to describe a broad aquatic setting, then defines strings from each of the five CMECS components, separated by an underscore (_):

The **s:** string defines the Surface Geology Component (SGC)
The **b:** string defines the Biotic Cover Component (BCC)
The **u:** string defines the Sub-Benthic Component (SBC)
The **g:** string defines the Geoform Component (GFC)
The **w:** string defines the Water Column Component (WCC)

The code sentence can incorporate strings for all components, but (for brevity) eliminates strings for which no data exist. The common code structure is defined as:

System.Subsystem_s:Surface Geology Class.Subclass.Group.Modifier_b:Biotic Class.Subclass.Group.*Biotope.*Modifier_u:Sub-Benthic Class.Subclass.Group.Modifier_ g:Physiographic Province.Geoform1.Geoform2.Anthrogeoform.Modifier_w:Water Column Hydroform.Biotic Group.*Biotope*.Modifier

Code labels or acronyms for most levels of CMECS are defined in the text and Appendices of this document within brackets, e.g., Aquatic Bed [AB]. Codes in the SGC have been well defined. In the BCC, codes for all levels except Biotope have been developed. Biotope code labels will follow a structure such that they are uniquely defined to include 8 italicized characters (which may include spaces). Biotope codes may be assigned as most appropriate to describe each type. For biotopes defined by a single species, the first letters of the Genus and species names of the defining organism may be used, so that a *Crassostrea virginica* oyster reef biotope may be *Cras Vir* in the code, or, where a biotope is identified by two co-occurring species, the 8 characters may include components of both organism names (*Baccharis halimifolia - Iva frutescens* Tidal Shrubland = BaHaIvFr). The naming scheme is flexible so that developers can avoid assigning the same code to different biotopes. Eight-character biotope labels will be developed as catalogues of biotopes are compiled.

Codes in the SBC have not been defined. In the GFC, codes are defined in Appendix F. The GFC allows multiple Geoforms, so the relevant part of the code structure captures "Geoform1.Geoform2", with as many Geoforms as are needed. In the WCC, hydroforms are defined by the first three letters of the term, except (as noted) where duplication would occur. Any modifiers for a component are captured at the end of the string for that component. A unique four-character acronym is used to code each modifier, and many of these codes have been assigned (see Chapter 8).

When data at the end of a string are missing (e.g., BCC class and subclass are known but biotic group and biotope are not) the convention is to simply leave off the end of the string. When data in the middle of a string are missing, the construct is to insert "0" or "00" so as to fit the expected number of missing digits (although, because the Modifier is an optional code, omission of a Modifier does not require insertion of 0's to denote the unknown next-highest level). When an entire string is missing, the convention is to leave it out entirely - - because the strings are identified to Component, a missing string does not disrupt other data. In this construct, any of the strings, either alone or together, may be used to describe an area. Figure 20, below, shows a hierarchy and coding for System/Subsystem, SGC, and BCC, and is intended to provide information for the code examples that follow.

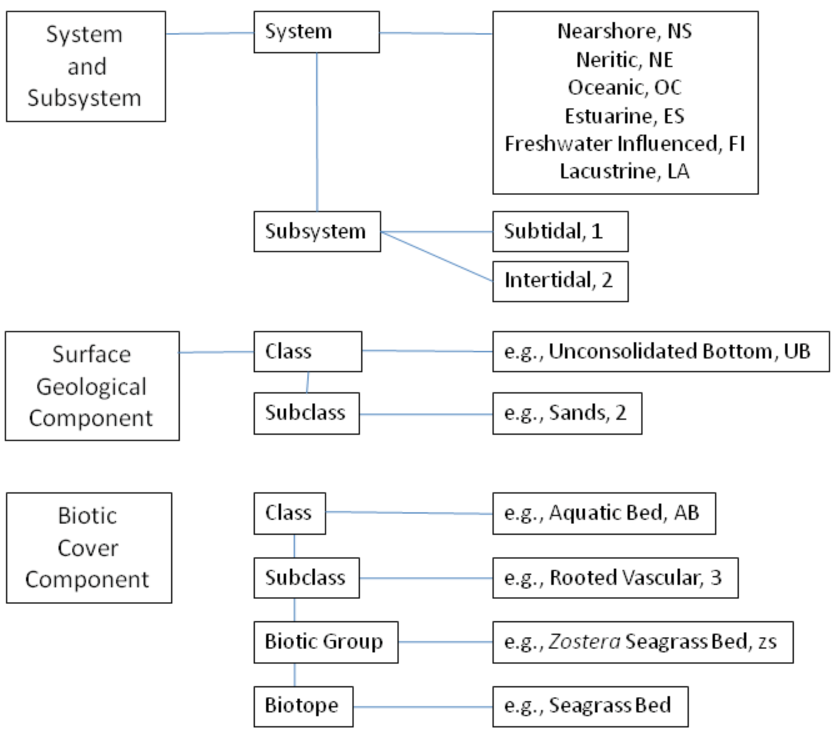


Figure 20. Example classifications of System, Subsystem, SGC, and BCC.

Examples of CMECS code structure based on Figure 20:

Estuarine subtidal sand substrate, biology cannot be resolved:
ES.1_s:UB.2

Estuarine subtidal sand substrate with BCC *Zostera* Biotic Group and *Zostera marina* biotope:
ES.1_s:UB.2_b:AB.3.zs.*Zost mar*

Estuarine subtidal, substrate cannot be resolved, with *Zostera* Biotic Group and *Zostera marina* biotope:
ES.1_b:AB.3.zs.*Zost mar*

Estuarine subtidal seagrass, species cannot be resolved, biotic group is unknown, substrate cannot be resolved:
ES.1_b:AB.3

Estuarine *Zostera* seagrass bed, species cannot be resolved, substrate cannot be resolved, and it is unclear if the area is intertidal or subtidal:
ES.0_b:AB.3.zs

Estuarine subtidal sand substrate with *Zostera* Biotic Group and *Zostera marina* biotope in a GFC Shoreline/Littoral Physiographic Province [10], with Lagoon [n], and Sandbar [sl] Geoforms:
ES.1_s:UB.2_b:AB.3.zs.*Zost mar*_g:10.n.sl

Estuarine subtidal sand substrate with Deep Infralittoral modifier [DInf], with BCC *Zostera* Biotic Group and *Zostera marina* biotope, with Dense Cover modifier [Dens]:
ES.1_s:UB.2.DInf_b:AB.3.zs.*Zost mar*.Dens

Estuarine subtidal sand substrate in a GFC Shoreline/Littoral Physiographic Province [10] and Riverine Estuary Geoform [er], in a WCC Turbidity maximum zone (Tur), biology cannot be resolved:
ES.1_s:UB.2_g:10.er_w:Tur

This code structure provides a concise descriptor and "repository" for CMECS classification data from any and all CMECS components. Different projects may characterize and partition the environment into many different types of habitats, and the intent behind this code structure is that any method of dividing up the environment can be captured in a code designation, which can then later be unpacked to inform other projects with different objectives. For example, consider an older geological map of an area of interest. CMECS codes can be assigned to polygons in this existing geological map, then, data from a more recent biological survey can be added using the same code structure. Years later, the combined code could easily be unpacked to inform a third project and synthesize new habitat maps that would address a new set of objectives different from those of the two initial data-gathering projects.

11. Glossary

Definitions provided in this glossary come from a variety of sources, including those indicated in the references below. Definitions cited with italicized references (e.g., *AGI*) may not be complete replications of the citation; rather, definitions have been adopted to provide the necessary substance in support of the concepts presented in CMECS. Definitions not cited can be found within the content of the CMECS document.

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Blaxter, J.H.S., F.S. Russell, and A.J. Southward. 1974. Advances in Marine Biology, Volume 23. Academic Press. 385 pages.

NOAA's Coral Reef Information System (*CoRIS*). Glossary of Terminology. http://www8.nos.noaa.gov/coris_glossary/index.aspx?letter=a

Wetzel, R.G. 2001. Limnology. Lake and River Ecosystems. Third Ed. Academic Press, San Diego. xvi, 1006 pp. ISBN 0-12-744760-1.

Abyssal: Pertaining to the ocean environment or depth zone of between 3,500 and 6,000 meters. *AGI.*

Abyssal Plain: A flat region of the deep ocean floor; slope less than 1:1,000; formed by the deposition of gravity-current and pelagic sediments that obscure the preexisting topography. *AGI.*

Abyssalbenthic: Pertaining to the benthos of the abyssal zone of the ocean. *AGI.*

Abyssalpelagic: Pertaining to the open-ocean or pelagic environment at abyssal depths. *AGI.*

Aggregate Reef: This Reef Morphology encompasses most low to moderate relief amorphous reef geomorphologies that do not readily fall into other Reef Morphologies.

Anchialine Pool (Lake): A land-locked brackish body of water that displays tidal fluctuations but has no surface connection to the sea; restricted to highly porous substrates, such as recently solidified molten rock or limestone adjacent to the sea. *CoRIS*

Anoxic: Oxygen level from 0-0.1 mg/L.

Anthropogenic: Made by people or resulting from human activities. *CoRIS.*

Aphotic Zone: That portion of the ocean where light is insufficient for plants or algae to carry on photosynthesis. *CoRIS.*

Apron: An extensive blanket-like deposit of alluvial unconsolidated material derived from an identifiable source, and deposited at the base of a mountain or seamount, or in front of a glacier, etc.; *e.g.* a bajada or an outwash plain. *AGI.*

Aquatic Bed: Vegetated or microbially-dominated subtidal or intertidal bottoms, or, any area (which might otherwise be classified as a Faunal Bed) that is characterized by greater than 10% cover of vascular plants, attached macroalgae, or microorganisms (and associated biota). Bed organisms are obligately hydrophilous, but may be able to withstand periods of exposure to air.

Artificial Reef: An artificial structure placed on the ocean floor to provide a hard substrate for sea life to colonize. Artificial reefs are constructed by sinking dense materials, such as old ships and barges, concrete ballasted tire units, concrete and steel demolition debris and dredge rock on the sea floor within designated reef sites. *CoRIS.*

Atoll: A ringlike coral island and reef that nearly or entirely encloses a reef lagoon; a coral reef appearing in plain view as a ring or horseshoe-shaped reef, rising from deep water of (1) the open sea, (2) a submarine bank or plateau of intermediate depth, or (3) a continental shelf. *AGI.*

Attached Algae: Macroalgae (seaweeds) living attached to any hard or soft substrate.

Back Reef: The shoreward side of a reef, including the area and sediments between the reefcrest/algal ridge and the land; corresponds to the reef flat and lagoon of a barrier reef and platform margin reef systems. *CoRIS.*

Bacterial Mat: Layer of bacteria growing on a substrate in densities that are clearly visible to the naked eye.

Bajada: A broad, continuous alluvial slope or gently inclined detrital surface, formed by the lateral coalescence of a series of separate but confluent alluvial fans, and having an undulating character due to the convexities of the component fans. *AGI.*

Bank: A mound-like or ridge-like submerged elevated area of modest to substantial extent, usually rising close to sea level.

Basin Floor: The area of the sea floor between the base of the continental margin, usually the foot of the continental rise, and the mid-ocean ridge. *AGI.*

Bathyl: Deep oceanic bottom areas between depths of 1000- 3500 meters.

Bathylbenthic: Pertaining to the benthos of the bathyl zone of the ocean.

Bathypelagic: A layer (zone) of the ocean water which lies just beneath the mesopelagic zone; extends from 1000-4000 meters; light source limited to bioluminescence; temperature remains fairly constant at about 4 C^{o}. *CoRIS.*

Bay: (a) A wide, curving open indentation, recess, or arm of a sea or lake into the land or between two capes or headlands, larger than a cove, and usually smaller than, but of the same general character as, a gulf. (b) A large tract of water that penetrates into the land and around which the land forms a broad curve. *AGI.*

Beach: A gently sloping zone formed by unconsolidated material at the shoreline, typically with a concave profile, extending landward from the low-water line to the place where there is a definite change in material or physiographic form (such as a cliff), or to the line of permanent vegetation (usually the effective limit of the highest storm waves); at the shore of a body of water, formed and washed by waves or tides, usually covered by sand or gravel, and lacking a bare rocky surface. *AGI.*

Bedrock: A general term for the rock, usually solid, that underlies soil or other unconsolidated, superficial material. *AGI.*

Benthic Boundary Layer: A thin water layer just above the substrate that is strongly influenced by the benthos and distinct from the overlying waters; often characterized by sharp reduction in current speeds, a nephelitic turbidity layer and high rates of diffusive interaction with biogeochemical components in the sediments; this layer is often strongly associated with small benthic or demersal organisms.

Berm: A low, impermanent, nearly horizontal or landward-sloping bench, shelf, ledge, or narrow terrace on the beach. *AGI.*

Bight: A long gradual bend or gentle curve, or a slight crescent-shaped indentation, in the shoreline of an open coast or of a bay; it may be larger than a bay, it may be a segment of a bay, or it may be a smaller feature than a bay. *AGI.*

Biotope: A repeatable physical habitat and its biological associations, uniform in structure and environment, defined by diagnostic taxa. These are broad associations identified by dominant or diagnostic species that are either fixed to the substrate or unattached but relatively non-motile for the benthic component, or by floating or suspended aggregations of biota for the water column component.

Blue Hole: A subsurface void developed in carbonate banks and islands, also offshore; open to the Earth's surface; contains tidally influenced waters of fresh, marine, or mixed chemistry; extends below sea level for the majority of its depth; and may provide access to cave passages. *AGI.*

Borderland (Continental): An area of the continental margin between the shoreline and the continental slope that is topographically more complex than the continental shelf; characterized by ridges and basins, some of which are below the depth of the continental shelf. *AGI.*

Bottom Water Column Layer: In a two-layer water column, the waters below the pycnocline or mixed layer compose the bottom water column layer.

Boulder: Detached rock greater than 256 mm in size; larger than cobble; often somewhat rounded or otherwise distinctively shaped by abrasion in the course of transport. *AGI.*

Branching Coral: Reef structure formed by a colony of small individual coral polyps creating a branched appearance.

Canyon (Submarine): A general term for all valleys of the deep-sea floor. *AGI.*

Canyon Channel: A relatively narrow sea or stretch of water between two close landmasses and connecting two larger bodies of water (usually seas). *AGI.*

Carbonate Mud: Fine particulates of calcium carbonate with high cohesiveness.

Channel: A general term for a linear or sinuous depression on an otherwise more flat area, e.g., a small or large valley-like or groove-like feature, usually associated with flow. See also **Active Channel, Bedrock Channel, Deep Sea Channel, Dredged Channel,** and **Tidal Channel**. *AGI.*

Channel (Active): (a) A generally linear or sinuous depression presently or periodically containing flow on a plain or valley bottom, or otherwise more flat area with multiple generations of channels. (b) The portion of a channel in which flow is present at the time of measurement, as opposed to the high-flow channel.

Channel (Bedrock): A channel with bedrock exposed along at least half of the bed and banks or with a sediment veneer that is largely mobilized during high flows, so that the underlying bedrock geometry strongly influences channel processes. *AGI.*

Channel (Deep Sea): A trough-shaped, low-relief valley on the deep-sea floor beyond the continental rise; it has few tributaries, and may be either parallel or at an angle to the continental margin. *AGI.*

Channel (Dredged): Coastal waters deepened by scraping and removing solids from the bottom, most often for purposes of navigation.

Channel (Tidal): A tidal inlet or major channel followed by the tidal currents, extending from offshore into a tidal marsh or a tidal flat. *AGI.*

Channel Bank: Definition of this feature is TBD.

Circalittoral Zone: Area extending from the lower limit of the infralittoral to the maximum depth at which photosynthesis is possible, e.g., 30 – 200 m. *Blaxter et al.*

Clay: Sediment size between silt and clay at either 2 or 4 micrometers. *AGI.*

Cliff: Any high, very steep to perpendicular or overhanging face of rock; a precipice; usually produced by erosion, less commonly by faulting. *AGI.*

Cobble: A rock fragment larger than a pebble and smaller than a boulder, having a diameter in the range of 64-256 mm; often somewhat rounded or otherwise modified by abrasion in the course of transport. *AGI.*

Coastal Salt Marsh (also referred to as **Coastal Marsh** or **Salt Marsh):** Areas dominated by emergent halophytic herbaceous vegetation or shrubs along low wave energy intertidal areas and river mouths. Coastal Salt Marsh is a wetland that has shallow water, and has levels that usually fluctuate due primarily to tides. Coastal salt marshes are primarily intertidal; that is, they are found in areas at least occasionally inundated by high tide but not flooded during low tide.

Coastal Water Mass: Definition of this feature is TBD.

Cold: Water temperature modifier ranging from 0-10° C.

Cold Core Rings: Large (roughly 300-km diameter) cyclonically rotating eddies found in the Sargasso Sea, containing cold slope water in their cores. They persist for several months, occasionally interacting with the Gulf Stream, which leads to their destruction. A cold-core ring is formed from a large-amplitude Gulf Stream meander that pinches off to the south, trapping relatively cold slope water from north of the Gulf Stream within its circumferential current. *http://amsglossary.allenpress.com/glossary/search?id=cold-core-rings1*.

Cone: A mountain, hill, or other landform shaped like a cone, having relatively steep slopes and a pointed top. *AGI.*

Continental Rise: That part of a continental margin that is between the continental slope and the abyssal plain; it is a gentle incline with slopes of 1:40 to 1:2,000 and generally smooth topography, although it may bear submarine canyons. *AGI.*

Continental Margin: The ocean floor that is between the shoreline and the abyssal ocean floor, including various provinces: the continental shelf, continental borderland, continental slope, and the continental rise. *AGI.*

Continental Shelf: That part of the continental margin that is between the shoreline and the continental slope (or, when there is no noticeable continental slope, a depth of 200 m); it is characterized by its very gentle slope of 0.1°. *AGI.*

Continental Shelf Break: The edge of the continental shelf, usually at a depth of 200m, where depths and slope begin to increase rapidly. The depth at which the Shelf Break occurs ranges from 100-200m. *AGI.*

Continental Slope: That part of the continental margin that is between the continental shelf and the continental rise if there is one; it is characterized by its relatively steep slope of 1.5° to 6°. *AGI.*

Convergence: A zone where ocean currents or water types or masses meet and mix; denser water mass will sink below the other, entraining some of the mixture; also, the line or area in which convergence occurs. *AGI.*

Coquina Sediment: Unconsolidated intertidal/supratidal sediments consisting almost exclusively of broken shell fragments.

Coral Garden: Aquatic beds dominated by non-reef forming corals including soft corals, gorgonians (sea fans, sea whips), sea pansies, etc, also including sponges and other sedentary or attached macroinvertebrates. Scattered hard corals may be present, but not dominant. Seagrass cover is less than 10%.

Coral Head: (a) A single massive, rounded coral colony; (b) A rounded, massive, often knobby or mushroom-shaped protuberance or growth of coral, usually forming on the submerged part of a coral reef, and frequently large enough to be dangerous to navigation. See also **Coral Knob**. *AGI.*

Coral Reef: A coral-algal or coral-dominated organic reef; a mound or ridge of in-place coral colonies and accumulated skeletal fragments, carbonate sand, and limestone resulting from organic secretion of calcium carbonate that lithifies colonies and sands; a coral reef is built up around a potentially wave- and surf-resistant framework, especially of coral colonies but often including many algae; the framework may constitute less than half of the reef volume. *AGI.*

Coralline Algae: Calcareous algae that form encrustations resembling coral. *AGI.*

Counter Current: A secondary current flowing in a direction opposite to that of the main current. *CoRIS.*

Crack: parting with crack-normal motion, e.g., where the movement of material separated by the crack is normal to the surface. See also, Fracture. *AGI.*

Crevice: A narrow opening or recess, as in a wave-eroded cliff or glacier. *AGI.*

Current: A horizontal movement or continuous flow of water in a given direction with a more or less uniform velocity, producing a perceptible mass transport, set in motion by winds, waves, gravity, or differences in temperature and density, and of a permanent or seasonal nature; esp. an ocean current. *AGI.*

Dam: An obstruction across a flow that is formed by either natural or anthropogenic processes so as to produce a lake, pond, or other widening. An alluvial dam is formed by a deposit of alluvium that is built by an overloaded stream and that obstructs its channel, thereby impounding water behind the deposit; a debris dam is formed by a mass of coarse alluvium deposited at the mouth of a tributary stream, commonly during a flash flood, and forming an obstruction in the main valley; a drift dam is formed by the accumulation of glacial drift in a pre-existing stream valley. *AGI.*

Deep-Sea Corals: Stony, soft, gorgonian, black, and horny corals that inhabit the colder deep waters of continental shelves and offshore canyons, ranging from 50-1000 m+ depths; lack zooxanthellae and may build reef-like structures or occur solitarily. *CoRIS.*

Delta: The low, nearly flat, alluvial tract of land at or near the mouth of a river, commonly forming a triangular or fan-shaped plain of considerable area, crossed by many distributaries of the main river, perhaps extending beyond the general trend of the coast, and resulting from the accumulation of sediment supplied by the river in such quantities that it is not removed by tides, waves, and currents. *AGI.*

Demersal: Pertains to an organism that is essentially bottom living but may feed and swim in the water column. *CoRIS.*

Density Current: A gravity-induced flow, owing to density differences with surrounding fluids; factors affecting density differences include temperature, salinity, and concentration of suspended particles. *AGI.*

Depression: Any relatively sunken part of the Earth's surface; esp. a low-lying area surrounded by higher ground and having no natural outlet for surface drainage, as an interior basin or a karstic sinkhole. *AGI.*

Detritus: Unconsolidated organic sediments composed primarily of fragments of dead organic matter, mostly soft plant or algal material.

Dike: An artificial wall, embankment, ridge, or mound, usually of earth or rock fill, built around a relatively flat, low-lying area to protect it from flooding; a levee. A dike may also be constructed on the shore or border of a lake to prevent inflow of undesirable water. *AGI.*

Divergence: The separation of ocean currents by horizontal flow of water in different directions from a common source; usually requires upwelling of water from depth to supply water to the divergence zone; also the area in which divergence occurs. *AGI.*

Downwelling: Sinking, as in the downward movement of surface water, generally caused by converging currents or by a water mass that becomes denser than the surrounding water. *AGI.*

Dredge Deposit: A location on the seafloor where materials from a dredging operation are placed.

Drift Algae: Macroalgae that are not attached and are moved by ocean currents and winds.

Drilling Platform: A large structure built to house workers and machinery needed to drill wells in the ocean bed, extract oil and/or natural gas, process the produced fluids, and ship them to shore; may be attached to the ocean floor, consist of an artificial island, or be floating. *http://en.wikipedia.org/wiki/Oil_platform.*

Dune: A sand dune on low-lying land recently abandoned or built up by the sea; the dune may ascend a cliff and travel inland. *AGI.*

Eddy: Circular current in the ocean, most frequently around 50-200 km in diameter. *AGI.*

Embayment: A bay, either the deep indentation or recess of a shoreline, or the large body of water (as an open bay) thus formed. *AGI.*

Emergent Wetland: BCC Class equivalent to the Emergent Wetland Class from the FGDC wetland standard (Cowardin et al, 1979) and characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants.

Enclosed Sea: A brackish or marine water body completed surrounded by land. *AGI.*

Crustose Algae: Submersed macrophytes with a prostate and encrusting morphology and generally with a stony or tough texture; may be calcified or uncalcified, *e.g.*, *Hildenbrandia*, *Lithothamnion*

Entrainment: The process of picking up and carrying along, as the collecting and movement of sediment by currents; can also be used as a noun to describe a WCC hydroform feature that is characterized by this process, e.g., an entrainment of clay sediments. *AGI.*

Epibenthic: Relating to the area on top of the sea floor; benthic organisms that live on top of the sediments, rocks, logs or plants; these organisms may be freely moving or sessile (permanently attached to a surface).

Epifauna: Benthic fauna living on top of and/or in association with the substrate or another solid surface. Epifauna may be sessile or mobile. Epifauna may be attached to a hard substrate or may live on top of or partly buried in soft sediments, with the majority of their body lying above the substrate.

Epipelagic: A vertical depth zone of the water column pertaining to the pelagic environment of the ocean to a depth of 200 meters; also, pertaining to the organisms inhabiting that zone. *AGI.*

Estuarine Lagoon: A lagoon produced by the temporary sealing of a river estuary by a barrier; such lagoons are usually seasonal and exist until the river breaches the barrier; they occur in regions of low or sporadic rainfall. *AGI.*

Estuarine System: Tidal habitats and adjacent tidal wetlands with water that is at least occasionally diluted by freshwater runoff from the land (<30PSU) and is at least partially enclosed by land but has open, partly obstructed, or sporadic access to the open ocean.

Euhaline: Waters measuring between 30 and 40 PSU.

Eutrophic: A situation in which the increased availability of nutrients such as nitrate and phosphate stimulates the growth of plants or algae such that the oxygen content is depleted and carbon sequestered. *CoRIS.*

Face: The principal side or surface of a landform; esp. rock face. [struc geol] The original top or upper surface of a layer of rock, esp. if it has been raised to a vertical or steeply inclined position. *AGI.*

Fan : A low, outspread, relatively flat to gently sloping mass of loose material, shaped like an open fan or a segment of a cone, deposited by a flow of water at the place where it issues from a narrower or steeper-gradient area into a broader area, valley, flat, or other feature. *AGI.* See also **Alluvial Fan**, **Basin-Floor Fan**, and **Shoreline Fan**.

Fan (Alluvial): A low, outspread, relatively flat to gently sloping mass of loose rock material, shaped like an open fan or a segment of a cone, deposited by a stream at the place where it issues from a narrow mountain valley upon a plain or broad valley, or where a tributary stream is near or at its junction with the main stream, or wherever a constriction in a valley abruptly ceases or the gradient of the stream suddenly decreases; it is steepest near the mouth of the valley where its apex points upstream, and it slopes gently and convexly outward with gradually decreasing gradient. *AGI.*

Fan (Basin-Floor): Deposition of submarine fans on the lower slope or basin floor; fan formation is associated with the erosion of canyons into the slope and the incision of fluvial valleys into the shelf; siliciclastic sediment bypasses the shelf and slope through the valleys and canyons to feed the basin-floor fan; may be deposited at the mouth of a canyon, although it may occur widely separated from the canyon mouth, or a canyon may not be evident. *AGI.*

Fan (Shoreline): A prograding shoreline formed where an alluvial fan is built out into a lake or sea. *AGI.*

Fault: A discrete surface or zone of discrete surfaces separating two rock masses across which one mass has slid past the other. *AGI.*

Faunal Bed: Subtidal or intertidal bottoms colonized with greater than 10% cover of sessile, infaunal, or slow moving animals and associated biota, and less than 10% cover of another structural biotic class (Faunal Reef, Coral Reef, Aquatic Bed). Faunal Bed organisms are obligately hydrophilous but may be able to withstand periods of exposure to air.

Faunal Reef: BCC or SGC Class describing the non-living structural component (SGC) or living biological component (BCC) of the ridge-like or mound-like structures or beds formed by the colonization and growth of mollusks, polychaetes, or any fauna other than corals. This Class occurs in both the intertidal and subtidal subsystems.

Fjord: A long, narrow, winding, glacially-eroded inlet or arm of the sea, U-shaped and steep-walled, generally several hundred meters deep, between high rocky cliffs or slopes along a mountainous coast; typically with a shallow sill or threshold of solid rock or earth material submerged near its mouth, and becoming deeper inland. *AGI.*

Flank: The definition of this feature is TBD.

Flat: A general term for a level or nearly level surface or area of land marked by little or no relief; often composed of unconsolidated sediments such as mud or sand. *AGI.*

Floating Macroalgae: Macroalgal accumulations at the surface, often formed by algae specifically adapted for the sea surface environment such as *Sargassum*.

Floating Microbial Mat: Microbial accumulations that occasionally form on the water surface as a film or scum.

Floating Vascular: Surface accumulations of detached vascular plants.

Floor: Bottom or bed, as in seafloor. *AGI.*

Forested Wetland: BCC Class equivalent to the Forested Wetland Class of the FGDC wetland standard (Cowardin et al, 1979) and characterized by woody vegetation that is generally 6 m or taller.

Forereef: This reef zone represents the section immediately seaward of the reef crest (where developed) or the beginning of significant reef development at the seaward end of a lagoon (where the reef crest is not developed). Depths range from 3-30 m and the slope is 0-5°. Much of the shallower portion of this zone is exposed to moderate wave energy, but the deeper portions are below fair weather wave base.

Fracture: (a) A general term for any surface within a material across which there is no cohesion, *e.g.* a crack; includes cracks, joints, and faults. (b) A crack in a rock where the movement of rock separated by the crack is normal to the surface. *AGI.*

Fracture Zone: On the deep-sea floor, an elongate zone of unusually irregular topography that often separates regions of different depths; zones commonly follow and extend beyond offsets of the mid-ocean ridge. *AGI.*

Freshwater Influenced System: Systems that have no distinct enclosing morphology, yet receive a significant amount of fresh water input from land during at least part of the year (<30 PSU); may be influenced by freshwater in the form of an active river plume, direct freshwater runoff, diffuse non-point runoff, an advected fresh water lens, mesohaline coastal water mass or a ground water seep discharge.

Freshwater Lens: The definition of this feature is TBD.

Fringing Reef: An organic reef that is directly attached to or borders the shore of an island or landmass, having a rough, table-like surface that is commonly exposed at low tide; it may be more than 1 km wide, and its seaward edge slopes sharply down to the sea floor; may be a shallow channel or lagoon between the reef and the adjacent mainland. *AGI.*

Frontal Boundary: The boundary between two different water masses.

Frozen: Water temperature modifier; $\leq 0°$ C with surface ice.

Geoform: Geomorphological features of the coastline and sea floor at multiple scales; equivalent in concept to a terrestrial landform (*e.g.*, mountain, butte, moraine etc) and likewise varies in size from very large (*e.g.*, seamount, embayment) to very small (*e.g.*, tidepool, ripple); geological features that shape the seascape in repeatable and predictable ways by providing structure, channeling energy flows, regulating bioenergetics, and controlling transfer rates of energy, material and organisms.

Groove: A sedimentary structure formed by closely spaced lines of straight-sided scour marks (Dzulynski and Sanders, 1962); scouring may be initially concentrated by a pre-existing groove. *AGI.*

Groundwater Seep: Subsurface water flowing into a coastal body of water. *CoRIS.*

Gully: The definition of this feature is TBD.

Guyot: A type of seamount that has a flat top. *AGI.*

Gyre: A closed geostrophic circulation in the ocean much larger than an eddy, e.g., the closed geostrophic circulation in each ocean basin centered on the subtropical high-pressure region. *AGI.*

Hadal: Pertaining to the deepest oceanic environment, specifically that of oceanic trenches, i.e., over 6,000 meters in depth. *AGI.*

Hadalbenthic: Pertaining to the benthos of the hadal zone of the ocean greater than 6000 meters.

Hadalpelagic: Deepest vertical depth zone of the water column; greater than 6000 meters.

Harbor: A small bay or a sheltered part of a sea, lake, or other large body of water, usually well protected either naturally or artificially against high waves and strong currents, and deep enough to provide safe anchorage for ships; esp. such a place in which port facilities are furnished. *AGI.*

Harbor Bar: A bar built across the exit to a harbor.

Hash: Subtidal bottom sediments principally comprised of mollusk or bivalve shell fragments mixed with sand or mud.

High Marsh: Salt marshes dominated by herbaceous emergent vegetation that are infrequently flooded by tides and are characterized by distinctive patterns of vegetation.

Hole: A deep place in a body of water. *AGI.*

Hot: Water temperature modifier >30° C.

Hummock: A rounded or conical knoll, mound, hillock, or other small elevation; a slight rise of ground above a level surface. *AGI.*

Hydroform: Large physical phenomena formed by water movements within a system that influence biotope composition.

Hydrothermal Plume: A cloud of hot, mineral-rich water that flows out of a hydrothermal vent and disperses into the ocean, usually several hundred meters above the seafloor vent site. Rock particles and minerals in the plume water often make the plume look smoky. *CoRIS.*

Hyperhaline: Water with a salinity higher than that of natural seawater, > 40 PSU.

Hypoxic: Deficient in oxygen; a WCC Modifier describing oxygen levels from 2 – 4 mg/L, intended to be used in conjunction with the WCC Modifier Severely Hypoxic, describing oxygen levels 0.1 – 2 mg/L

Ice Feature: The definition of this feature is TBD.

Ice Hummock: A mound, hillock, or pile of broken floating ice, either fresh or weathered, that has been forced upward by pressure, as in an ice field or ice floe. *AGI.*

Infauna: Organisms that live with the majority of their body below the sediment surface, although feeding or respiratory appendages commonly extend into the water column.

Infralittoral: The region of subtidal water from closest to the shore to the depth where plants and algae can grow. *http://www.seafriends.org.nz/enviro/habitat/index.html.*

Inland Sea (Epicontinental Sea): A sea on the continental shelf or within a continent. *AGI.*

Inlet: A general term describing: (a) a small, narrow opening, recess, indentation, or other entrance into a coastline or a shore of a lake or river, through which water penetrates into the land; (b) a waterway entering a sea, lake, or river; a creek; an inflowing stream; or (c) a short, narrow waterway between islands, or connecting a bay, lagoon, or similar body of water with a larger body of water, such as a sea or lake; *e.g.* a waterway through a coastal obstruction (such as a reef or a barrier island) leading to a bay or lagoon. *AGI.* See also **Migrating Inlet** and **Tidal Inlet**.

Inlet (Migrating): A tidal inlet, such as that connecting a coastal bay with the open sea, that shifts its position laterally in the direction in which the dominant longshore current flows; it results from deposition on one side of the inlet, accompanied by erosion on the other. *AGI.*

Inlet (Tidal): Any inlet through which water alternately floods landward with the rising tide and ebbs seaward with the falling tide; specif. a natural inlet maintained by tidal currents. *AGI.*

Internal Wave: A wave occurring on an internal density surface in a stratified ocean, *e.g.*, a wave on the thermocline; wave heights, periods, and lengths are much greater than surface wave heights, periods, and lengths. *AGI.*

Intertidal: Subsystem where substrate is regularly and periodically exposed and flooded by tides; includes the supratidal zone -- the area above the high tide line in the splash zone that is affected by spray, splash, aerosols and overwash; this interface is regularly exposed to the air by tidal movement.

Island: A tract of land smaller than a continent, surrounded by the water of an ocean, sea, lake, stream, swamp, or marsh, or isolated at high water or during floods. See also **Oceanic Island.** *AGI.*

Island (Oceanic): Island either composed of basalt or of biogenic origin (coral reef, etc.), as distinguished from islands having rocks characteristic of continents; beaches of true oceanic islands consist of rock fragments or of coral and shell debris, and have a dark, white, or reddish appearance and lack white quartz sand, the most characteristic component of continental beaches. *AGI.*

Island Rise: An area of the ocean floor analogous to the continental rise, but surrounding an island.

Island Shelf (also referred to as **Insular Shelf):** An area of the ocean floor analogous to the continental shelf, but surrounding an island. *AGI.*

Island Slope (also referred to as **Insular Slope):** An area of the ocean floor analogous to a continental slope, but surrounding an island. *AGI.*

Jetty: (a) An engineered structure (such as a groin) extending more or less perpendicularly from the shore into a body of water and designed to direct and confine the current or tide, to protect a harbor, or to prevent shoaling of a navigable inlet by littoral materials; generally larger than a groin. *AGI.*

Karst: A limestone terrain characterized by sinks, caverns, abrupt ridges, protuberant rocks and drainage characteristics due to greater solubility of limestone in natural waters. *CoRIS*

Kelp: Any of numerous large seaweeds found in colder seas and belonging to the order Laminariales (about 30 genera) of brown algae. *http://en.wikipedia.org/wiki/Kelp.*

Knob: A rounded eminence, as a knoll, mound, or other geologic protruberance esp. a prominent or isolated mound with steep sides, also including peaks or other projections from seamounts, or groups of boulders or other protruding areas of resistant rocks See also **Coral Knob.** *AGI..*

Knob (Coral): see **Coral Head**. *AGI.*

Lacustrine System: Includes wetlands and deep, freshwater habitats with all of the three following characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30 percent areal coverage; and (3) total area exceeds 8 ha (20 acres); similar wetland and deep, freshwater habitats totaling less than 8 ha are also included if an active wave formed or bedrock shoreline feature makes up all or part of the boundary or if the water depth in the deepest part of the basin exceeds 2 meters (6.6 feet) at low water; waters may be tidal or nontidal, but ocean-derived salinity is always less than 0.5 parts per thousand; the boundary between wetland and deep, freshwater habitats lies at a depth of 2 meters (6.6 feet) below water; however, if emergents, shrubs, or trees grow beyond this depth, their deepwater edge is the boundary. *Cowardin et al.*

Lagoon: A mostly-enclosed, shallow, saline water body with little freshwater input and damped tidal fluxes; generally small in size. See also Reef Lagoon.

Lagoon (Reef): Coral Reef SGC Subclass describing the geomorphological depression found between a coral reef flat/crest (where developed) or the forereef and shore. Depths commonly range from 0-50 m, and the environment is very low energy, resulting in the accumulation of sediments, typically finer grained than other zones of the coral reef.

Landslide: A general term covering a wide variety of mass-movement landforms and processes involving the downslope transport, under gravitational influence, of soil and rock material en masse; usually preceded, accompanied, and followed by perceptible creep along the surface of sliding and/or within the slide mass. *AGI.*

Langmuir Cell: A unit of water circulation, at or adjacent to the surface, driven by the wind, having its long axis essentially parallel with the wind direction, having opposite senses of spiral flow in adjacent cells, and having pronounced ellipticity in shallow water, where it may influence sediment transport. *Wetzel 2001*.

Lava Field: A more or less well-defined area that is covered by lava flows. *AGI.*

Ledge: A rocky outcrop or underwater ridge of rocks, esp. near the shore.

Levee: A general term describing an embankment of sediment, bordering one or both sides of a submarine canyon, fan valley, deep-sea channel, river, or other feature. *AGI.* See also **Artificial Levee, Delta Levee**, and **Lava Levee**.

Levee (Artificial): A dike along the side of a river channel erected to prevent overflow during floods, ordinarily running more or less along the channel direction and near the natural levee crests of alluviating streams; also used for structures designed to prevent flooding by seas, lakes, etc. *AGI.*

Levee (Delta): A delta having the form of a long narrow ridge, resembling a natural levee. *AGI.*

Levee (Lava): The scoriaceous sheets of lava that overflowed their natural channels and solidified to form a levee, similar to levees formed by an overflowing stream of water. *AGI.*

Linear Reef: Linear reef typically fringes shorelines or forms in deeper water (3-20 m) as the terminus of a Reef Lagoon [1]. Linear reef relief can be 1-10 m above the surrounding substrate, and is typically oriented parallel to shore. Reef crests [4] are almost always linear reef by definition. This Reef Morphology occurs most commonly in Reef Lagoon [1], Reef Crest [4], and Forereef [5] Subclasses, and rarely in others.

Littoral: Intertidal; between low and high tide levels. *CoRIS.*

Low Marsh: Salt marshes that are regularly flooded by tides so as to support characteristic halophytic vegetation.

Macroalgae: Submersed non-vascular macrophyte vegetation.

Mangrove: Tidally-influenced, dense tropical or subtropical forest with a shore zone dominated by true mangroves and associates.

Marine: Waters that receive no freshwater input from land and generally have full oceanic salinity (>30 psu) throughout the year.

Mesohaline: Waters with a salinity range of 5 – 18 psu.

Mesobenthic: Pertaining to the benthos of the ocean zone between 200 and 1000 meters.

Mesopelagic: A vertical depth zone of the water column pertaining to the pelagic environment of the ocean between 200 and 1000 meters. *AGI.*

Mesotrophic: Trophic status indicates waters having moderate productivity, 5.0 – 50.0 µg/L chlorophyll a.

Microbial Mat: Thick colonies of microbes often found in extreme environments (*e.g.*, extreme temperatures, hypersaline waters); reduced competition and predation from multicellular life under these extreme conditions allows microbes to thrive.

Microphytobenthos: Visible accumulations of benthic diatoms, cyanobacteria, unicellular algae and other groups forming a film, crust, or "felt" at the surface of the substrate.

Mid-ocean Ridge: A continuous, seismically active, median mountain range extending through the North and South Atlantic Oceans, the Indian Ocean, and the South Pacific Ocean; it is a broad, fractured swell with a central rift valley and usually extremely rugged topography, 1-3 km in height, about 1,500 km in width, and over 84,000 km in length. *AGI.*

Mixed Sediments: A relatively homogeneous mix of sediment sizes where no single unconsolidated substrate type represents more than 50% of the total composition.

Modifier: Attributes of a habitat that provide additional environmental, structural, or biotic information about the type that is useful for description and application, but are not required to classify it.

Mollusk Reef: Consolidated aggregations of living and dead mollusks, usually bivalves (*e.g.*, oysters, mussels) or gastropods (*e.g.*, vermetids) attached to their conspecifics.

Moraine: A mound, ridge, or other distinct accumulation of unsorted, unstratified glacial drift, predominantly till, deposited chiefly by direct action of glacier ice, in a variety of topographic landforms that are independent of control by the surface on which the drift lies. *AGI.*

Mound: A low, rounded, hill-like feature, may be composed of a variety of materials. *AGI.*

Mud: Greater than 50% of the unconsolidated particles smaller than boulders are silt and clay or carbonate mud (grain size <0.07 mm). Anaerobic conditions often exist below the surfaces and often have a higher organic content than cobble-gravel or sand shores or benthos.

Mussel Bed: Low-relief beds formed by the colonization and aggregation of mussels.

Nearshore System: Waters that are truly marine in character (> 30 PSU throughout the year); extends from the land margin to the 30 meters depth contour; the proximity of land and nearshore processes strongly influences waters and benthos of these systems although the biota and physics are marine.

Nephelitic: Particle-rich, describing zones in the water column; see also Nepheloid Layer.

Nepheloid Layer: A layer of water that contains significant amounts of suspended sediment. In the deep ocean, it can be from 200 m to 1,000 m thick. *AGI.*

Neritic System: Marine waters (> 30 psu year round) between the 30 meters depth contour and the continental shelf break, which occurs at approximately at 200 meters water depth.

Non-stratified: Water masses that do not contain stable horizontal layers of different densities, and are consequently relatively well-mixed.

Notch: A deep, narrow cut or hollow along the base of a sea cliff near the high-water mark, formed by undercutting due to wave erosion and/or chemical solution, and above which the cliff overhangs. *AGI.*

Oceanic Bank: A mound-like or ridge-like submerged elevated area on the sea floor of modest to substantial extent, usually close to sea level (*e.g.*, Bahama banks). *AGI.*

Oceanic System: The marine realm beyond the continental shelf break; waters that are generally deeper than 200 meters.

Oligohaline: Waters with a salinity range of >0 – 5 PSU.

Oligotrophic: Trophic status indicates low productivity, < 5 µg/L chlorophyll a.

Ooze: A pelagic sediment consisting of at least 30% skeletal remains of pelagic organisms (either calcareous or siliceous), the rest being clay minerals. Grain size is often bimodal (partly in the clay range, partly in the sand or silt range); further defined by their characteristic organisms: diatom ooze; foraminiferal ooze; globigerina ooze; pteropod ooze; radiolarian ooze. *AGI.*

Organic: Unconsolidated substrate largely comprised of decomposing particles of dead plant and animal tissue.

Organic Matter: The organic fraction of the soil exclusive of undecayed plant and animal residues. *AGI.*

Overbank Deposit: Fine-grained sediment (silt and clay) deposited from suspension on a floodplain by floodwaters that cannot be contained within the stream channel. *AGI.*

Overhang (Cliff): A rock mass jutting out from a slope; esp. the upper part or edge of an eroded cliff projecting out over the lower, undercut part, as above a wave-cut notch. *AGI.*

Oxic: An environment in which oxygen is present at a concentration of 4 – 10 mg/L. *http://www.biology-online.org/dictionary/Oxic.*

Oxygen Minimum Layer: A depth zone, usually below the thermocline, in which dissolved oxygen is minimal. *Http://life.bio.sunysb.edu/marinebio/glossary.def.html.*

Oxygen Saturated: For consistency, CMECS defines Oxygen Saturated as an environment where oxygen is found at a concentration between 10-12 mg/L

Oxygen Supersaturated: For consistency, CMECS defines Oxygen Saturated as an environment where oxygen is found at a concentration above >12 mg/L

Oyster Reef: An organic reef composed mostly of oyster shells attached upon one another in growth position; living examples tend to be small (a hundred meters or so across, by a few meters high) and to occur in estuarine waters. *AGI.*

Patch Reef: Reefs that are somewhat isolated, relatively circular to amoeboid reef accretions spanning one meter to tens of meters. Patch reefs typically rise 1-10 m above the surrounding substrate, and in many cases are circled by a sand "halo".

Pavement: Flat, generally unbroken hard bottom substrate formed by deposition and consolidation of material and overlying a deeper bedrock substrate.

Peat: An unconsolidated deposit of semi-carbonized plant remains in a water-saturated environment, and of persistently high moisture content (at least 75%); an early stage in the development of coal; carbon content is about 60% and oxygen content is about 30% (moisture-free). *AGI.*

Pelagic: (a) Pertaining to the water of the ocean as an environment; (b) Said of marine organisms whose environment is the open ocean, rather than the bottom or shore areas; pelagic organisms may be either nektonic or planktonic. *AGI.*

Peninsula: (a) An elongated body or stretch of land nearly surrounded by water and connected with a larger land area, usually by a neck or an isthmus. (b) A relatively large tract of land jutting out into the water, with or without a well-defined isthmus. *AGI.*

Pier: A breakwater, groin, mole, or other structure used to protect a harbor or shore, and serving also as a promenade or as a landing place for vessels. *AGI.*

Photic Zone: The depth zone in the ocean extending from the surface to that depth permitting photosynthesis. *Http://life.bio.sunysb.edu/marinebio/glossary.def.html.*

Photic Quality: A measurement of light penetration to describe areas where plants can photosynthesize and animals can feed and defend visually versus where they cannot.

Phytoplankton: The photosynthesizing organisms residing in the plankton. *Http://life.bio.sunysb.edu/marinebio/glossary.def.html.*

Pilings: A structure formed by piles which are long, slender columns, usually made of timber, steel, or reinforced concrete. *http://www.merriam-webster.com/dictionary/pilings.*

Pit: A small indentation or depression.

Plate: A thin flat fragment of rock, such as a slab or flagstone.

Tectonic Plate: A torsionally rigid thin segment of the Earth's lithosphere, which may be assumed to move horizontally and adjoins other plates along zones of seismic activity. *AGI.*

Plume: A featherlike flow, often as a flow from one area or body of water into another, e.g., polluted water entering a river. *AGI.*

Plunging Current: This definition is TBD.

Pockmark: A concave crater-like depression; range in diameter from 15 to 45 meters and in depth from 5 to 10 meters; origin may be due to gas escape. *AGI.*

Polyhaline: Waters with a salinity range of 18-30 PSU.

Prop Scar: An area, generally in aquatic vegetation, where damage from boat props has left a permanent disturbance.

Pycnocline: (a) The depth of the maximum rate of increase of density with depth, the depth of the maximum of the vertical density gradient. (b) More generally, the region of large vertical density gradients below the mixed layer. *AGI.*

Reef: A large ridge or mound-like structure within a body of water that is built by organisms such as corals, red algae, worms, or bivalves.

Reef Crest: The sharp break in slope at the seaward margin or edge of the reef flat, located at the top of the reef front; marked by dominance of a particular coral species or by an algal ridge and/or surge channels. *AGI.*

Reef Flat: A stony platform of reef rock, landward of the reef crest at or above the low tide level, occasionally with patches of living coral and associated organisms, and commonly strewn with coral fragments and coral sand; may include shallow pools, irregular gullies, low islands of sand or rubble, and scattered colonies of the more hardy species of coral. *AGI.*

Reef Halo: A zone of unconsolidated sediments, usually calcareous sands, that surrounds a patch reef.

Rhodolith: A nodule of red (coralline) algae, concentrically encrusted, often rolled by bottom currents. *AGI.*

Ridge: An elongate, steep-sided elevation, generally having rough topography.

Rill: (a) A small, transient runnel carrying to the sea or a lake the water of a wave after it breaks on a beach, esp. one formed following an outgoing tide. It may be 2-10 mm wide, 0.5 m or more long, and about 1 mm deep. (b) The minute stream or thin sheet of water flowing in a rill. *AGI.*

Rock Bottom: Subtidal benthic substrates having a cover of large rocks, boulders, pavement or bedrock 75% or greater and vegetative cover of less than 10%.

Rock Outcrop: That part of a geologic formation or structure that appears at the surface of the Earth;

Rocky Shore: Exposed intertidal shoreline characterized by bedrock or boulders which singly or in combination have an aerial cover of 75% or more and an aerial coverage by vegetation of less than 10%.

Rooted Vascular: Aquatic beds dominated by submerged rooted vascular species such as seagrasses. Seagrass beds are complex structural habitats which provide refuge and foraging opportunities for abundant and diverse faunal communities.

Rubble Zone: A loose mass of angular rock fragments, commonly overlying outcropping rock; the unconsolidated equivalent of a breccia. *AGI.*

Salt Wedge: A wedge-shaped mass of salt water from an ocean or sea which intrudes the mouth and lower course of a river; the denser salt water underlies the fresher river water. *AGI.*

Sand: Unconsolidated particles smaller than boulders are sands (particles 0.07-2 mm) which may be calcareous, terrigenous, or may derive from some other source.

Sand Ripple: A ripple composed of sand. *AGI.*

Sand Wave: (a) A general term for a wavelike bed form in sand. (b) A generally large and asymmetrical bed form in sand, with a wavelike form but lacking the deep scour associated with dunes and megaripples. (c) A general term to describe very large subaqueous sand ripples. *AGI.*

Scattered Coral/Rock: Scattered rocks or small, isolated coral heads (*i.e.*, smaller than individual patch reef).

Scarp: (a) A line of cliffs produced by faulting or by erosion. (b) A relatively straight, cliff-like face or slope of considerable linear extent, breaking the general continuity of the land by separating surfaces lying at different levels, as along the margin of a plateau or mesa. *AGI.* See also **Beach Scarp**.

Scarp (Beach): An almost vertical slope on a beach, caused by wave erosion; may range in height from several centimeters to a few meters, depending on the character of the wave action and the nature and composition of the beach; common on recently nourished beaches. *AGI.*

Scour Mark: A current mark produced by the cutting or scouring action of a current of water flowing over the bottom. *AGI.*

Sea Surface: A vertical zone of the water column defined only by depth of the water; zero meters.

Seabed: Subtidal ocean bottom, completely covered by the water at all times; distinct from the bottom within the littoral intertidal zone.

Seamount: An elevation of the sea floor, 1000 meters or higher, either flat-topped (called a guyot) or peaked (called a seapeak); seamounts may be either discrete, arranged in a linear or random grouping, or connected at their bases and aligned along a ridge or rise. *AGI.*

Seasonally Photic: The water column regularly varies between photic and aphotic on a seasonal basis.

Seawall: A man-made wall or embankment of stone, reinforced concrete, or other material along a shore to prevent wave erosion. *AGI.*

Sediment Wave: A concept of sediment transport through time in a form analogous to a storm hydrograph with a rising and falling limb and a peak instantaneous discharge rate. *AGI.*

Shelf Break: An abrupt change in slope, marking the boundary between the continental shelf and the continental slope, generally between 100 – 200 meters; the physiographic province in a basin defined by a change in dip from the shelf (dipping less than 1:1000 landward of the shelf break) to the slope (dipping more than 1:40 seaward of the shelf break). *AGI.*

Shoal: A relatively shallow place in a stream, lake, sea, or other body of water, typically a submerged ridge, bank, or bar consisting of or covered by sand or other unconsolidated material, but may also be composed of rock or other material

Silt: A rock fragment or detrital particle smaller than a very fine sand grain and larger than coarse clay, having a diameter in the range of 1/256 to 1/16 mm (4-62 micrometers, or 0.00016-0.0025 in., or 8 to 4 phi units; the upper size limit is approximately the smallest size that can be distinguished with the unaided eye). *AGI.*

Sink: A depression containing a central playa or saline lake with no outlet, as where a desert stream comes to an end or disappears by evaporation. *AGI.*

Slough: A small marsh or sluggish body of water in a tidal flat, bottomland, or coastal marshland.

Slump: (a) A landslide characterized by a shearing and rotary movement of a generally independent mass of rock or earth along a curved slip surface (concave upward) and about an axis parallel to the slope from which it descends, and by backward tilting of the mass with respect to that slope so that the slump surface often exhibits a reversed slope facing uphill. (b) The sliding-down of a mass of sediment shortly after its deposition on an underwater slope; especially the downslope flowage of soft, unconsolidated marine sediments, as at the head or along the side of a submarine canyon. *AGI.*

Solution Pit: An indentation up to about 1 mm in diameter formed on a rock surface by solution. *AGI.*

Sound: A relatively long, narrow waterway connecting two larger bodies of water (*e.g.*, a sea or lake with the ocean or another sea); also two parts of the same body, or an arm of the sea forming a channel between a mainland and an island. *AGI.*

Sponge Bed: A biotope characterized by areas of the seafloor where the dominant faunal cover consists of sponges and their associated communities. Hexactinellid "glass sponges" are common deep-sea biotopes; other sponge groups may dominate coastal epifauna.

Spreading Center: Mid-ocean ridge. *AGI.*

Spur and Groove Reef: A system of shallow ridges (spurs) separated by deep channels (grooves) oriented perpendicular to the reef crest and extending down the upper seaward slope. *CoRIS.*

Streambed: The channel containing or formerly containing the water of a stream. *AGI.*

Sub-estuary: A semi-enclosed water body that otherwise meets the definition of an estuary, but empties into a larger estuary rather than into the ocean.

Sublittoral: All areas permanently covered by water.

Submarine Canyon: Submerged earthform consisting of an incised large submarine feature on a slope normally associated with the continental shelf but also found on the continental slope. *AGI.*

Subtidal: Permanently below the level of low tide; a continually underwater environment. *CoRIS.*

Superchilled: A water temperature modifier describing conditions $\leq 0°$ C and without ice.

Supratidal: Above the level of high tide; a terrestrial environment that is influenced by proximity to the sea. Such influences include sea spray, sea breezes and aeolian processes, and geological and biological "spillover" such as dune development. *CoRIS.*

Surf: (a) The wave activity in the surf zone. (b) A collective term for breakers. *AGI.*

Surf Zone: The area bounded by the landward limit of wave uprush and the farthest seaward breaker. *AGI.*

Surface Wave: A progressive gravity wave in which the particle movement is confined to the upper limits of a body of water; strictly, a gravity wave whose celerity is a function of wavelength only. *AGI.*

Swale: A long, narrow, generally shallow, trough-like depression between two beach ridges, and aligned roughly parallel to the coastline. *AGI.*

System: Broad ecological units differentiated from one another by a combination of salinity, geomorphology and depth.

Temperate: Pertaining to the latitudinal belt between 23º 27' and 66º 33' north or south latitude. *CoRIS.*

Terrace: Any long, narrow, relatively level or gently inclined surface, generally less broad than a plain, bounded along one edge by a steeper descending slope and along the other by a steeper ascending slope; a large bench or step-like ledge that breaks the continuity of a slope. May be created by erosion, wave action, uplift, currents, or any other process. *AGI.*

Tidal Creek: A smaller distributary off a tidal channel within a marsh or flat.

Tidal Shrubland: Communities dominated by low shrub halophytic vegetation along low-wave energy intertidal areas and river mouths.

Tidepool: A pool of salt water left by an ebbing tide. *AGI.*

Trawl Disturbance: An area of the seafloor impacted by trawling activities.

Trawler: A fishing vessel that tows an open-mouthed fishing net drawn along the sea bottom or in the water column. *CoRIS.*

Trench: A narrow, elongate depression of the deep-sea floor associated with a subduction zone; oriented parallel to a volcanic arc and commonly to the edge of the adjacent continent, between the continental margin and the abyssal hills; commonly two or more km deeper than the surrounding ocean floor, and may be thousands of kilometers long. *AGI.*

Turbidity: The state, condition, or quality of opaqueness or reduced clarity of a fluid, due to the presence of suspended matter. *AGI.*

Turbidity Current: A density current in water, air, or other fluid, caused by different amounts of matter in suspension, such as a dry-snow avalanche or a descending cloud of volcanic dust; specif. a bottom-flowing current laden with suspended sediment, moving swiftly (under the influence of gravity) down a subaqueous slope and spreading horizontally on the floor of the body of water, having been set and/or maintained in motion by locally churned- or stirred-up sediment that gives the water a density greater than that of the surrounding or overlying clear water. *AGI.*

Unconsolidated Bottom: Substrates having at least 25% cover of particles smaller than boulders, and a vegetative cover less than 10%; a sediment that is loosely arranged or unstratified, or whose particles are not cemented together.

Unconsolidated Shore: Exposed intertidal unconsolidated shoreline having at least 25% cover of particles smaller than stones, and a vegetative cover less than 10%.

Upper Water Layer: In a two-layer water column, the area above the sharp density gradient (pycnocline) which includes the air-water interface.

Upwelling: The rising of subsurface water toward the surface, especially along the western coasts of continents; it replaces surface water that is transported away from the coast by Ekman mass transport driven by equatorward winds; also occurs in the open ocean along the equator and in association with cyclonic circulation; areas of upwelling are commonly marked by anomalously cold temperature and high productivity. *AGI.*

Vent: The areas at the Earth's surface through which materials related to volcanic activity are extruded; also, the channel or conduit through which they pass. *AGI.*

Volcanic Plain: Surface formed by extensive lava or ash flows that cover topographic irregularities. *AGI.*

Wall: A general term describing any large near-vertical feature composed of rock or other material. See also Reef Wall.

Wall (Reef): (a) A wall-like upgrowth of living coral and the skeletal remains of dead coral and other reef-building organisms, reaching intertidal level where it acts as a partial barrier between adjacent environments; an elongate reef core. (b) Near-vertical to overhanging wall developed on sea-facing reef margins below the zone of shallow reef growth (ca. 30 m) and extending to depths of ca. 150 m in the Caribbean. *AGI.*

Warm: Water temperature modifier ranging from 20-30° C.

Warm Core Ring: Large (roughly 300 km diameter) anticyclonically rotating eddies found in the slope waters to the north of the Gulf Stream, containing Sargasso Sea water in their core. *http://amsglossary.allenpress.com/glossary/search?id=warm-core-rings1.*

Woody Debris: Coarse partially decomposed, recalcitrant, woody plant material from trees and shrubs.

Worm Reef: A small organic reef built by wormlike organisms. *AGI.*

Zooplankton: Animal component of the plankton community. *CoRIS.*

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Appendix A – System and Subsystem Units

System	Subsystem
Estuarine [ES]	Subtidal [1]
	Intertidal [2]
Nearshore [NS]	Subtidal [1]
	Intertidal [2]
Neritic [NE]	
Oceanic [OC]	
Freshwater Influenced [FI]	Subtidal [1]
	Intertidal [2]
Lacustrine [LA]	Limnetic [1]
	Littoral [2]

Appendix B – Surface Geology Component

System	Subsystem	Class	Subclass	Reef Morphology
Estuarine [ES]	Subtidal [1]	Rock Bottom [RB]	Bedrock [1]	
Nearshore [NS]	Intertidal [2]		Boulder [2]	
Neritic [NE]		Unconsolidated Bottom [UB]	Cobble/Gravel [1]	
Oceanic [OC]			Sands [2]	
Freshwater Influenced [FI]			Muds [3]	
Lacustrine [LA]			Organic [4]	
			Shell [5]	
			Mixed Sediments [6]	
			Reef Rubble [7]	
		Rock Shore [RS]	Bedrock [1]	
			Boulder [2]	
		Unconsolidated Shore [US]	Cobble/Gravel [1]	
			Sands [2]	
		Faunal Bed [FB]	Muds [3]	
			Organic [4]	
			Shell [5]	
			Mixed Sediments [6]	
			Reef Rubble [7]	
		Coral Reef [CR]	Reef Lagoon [1]	Spur and Groove Reef [a]
			Back Reef [2]	Patch Reef [b]
			Reef Flat [3]	Aggregate Patch Reef [c]
			Reef Crest [4]	Linear Reef [d]
			Forereef [5]	Aggregate Reef [e]
			Deep Forereef [6]	Live Hardbottom [f]
			Pinnacle Reef [7]	Scattered Coral/Rock on Unconsolidated Bottom [g]
			Mesophotic Reef [8]	
			Deep Cold-Water Reef [9]	
			Outlier Reef [10]	

Appendix C – Biotic Cover Component Units

Class	Subclass	Biotic Group	Biotope
Faunal Reef [FR]	Mollusk Reef [1]	Oyster Reef	*Ostrea* reef, *Crassostrea* reef
		Mussel Reef	*Mytilus* reef, *Modiolus* reef
		Gastropod Reef	Vermetid reef, *Crepidula* reef
	Worm Reef [2]	Worm Reef	*Phragmatopoma* reef, *Sabellaria* reef
Coral Reef [CR]	Living Stony Coral Communities [1]	Robust Branching Corals	*Acrophora palmata* Reef
		Fragile Branching Corals	*Acropora* Reef, Porites Reef, Madracis Reef, Oculina Reef, Lophelia Reef, Pocillopora Reef.
		Table Corals	*Acropora* Reef
		Massive Corals	*Diploria* Reef, *Montastraea* Reef, *Montipora* Reef, *Porites* Reef
		Plate Corals	*Agaricia* Reef, *Montastraea* Reef
		Encrusting Corals	*Millepora* Reef, *Porites* Reef
	Calcareous Algal Communities [2]	Rhodolith Beds	*Lithothamnion* communities, *Lithophyllum* communities
		Crustose Calcareous Algae	
		Upright Calcareous Algae	*Halimeda* communities.
Faunal Bed [FB]	Sessile Epifauna [1]	Oyster Bed	*Ostrea* communities, *Crassostrea* communities
		Mussel Bed	*Mytilus* communities, *Modiolus* communities
		Sessile Gastropods	*Crepidula* communities, vermetid communities
		Barnacles	*Chthamalus* communities, *Balanus* communities
		Coral Garden	Mixed soft coral communities, gorgonian communities
		Mixed Colonizers	Virginian mixed colonizing communities, deep-water Northern Gulf of Mexico mixed colonizing communities
		Sponge Bed	*Microciona* communities, *Hyalonema* communities
		Attached Anemones	*Metridium* communities
		Burrowing Anemones	*Cerianthus* communities, *Edwardsia* communities
		Small Tube-Building Fauna	*Ampelisca* communities, *Polydora* communities, *Streblospio* communities, *Paraprionospio* communities
		Larger Tube-Building Fauna	*Chaetopterus* communities, *Lagis* communities, *Diopatra* communities, *Asychis* communities, *Asabellides* communities, *Loimia* communities

Class	Subclass	Biotic Group	Biotope
		Crinoids	*Diplocrinus* communities, *Comanthus* communities
		Hydroids	*Sertularia* communities, *Tubularia* communities
		Bryozoans	*Bugula* communities, *Celleporaria* communities
		Tunicate Bed	*Didemnum* communities, *Molgula* communities
		Foraminifera	xenophyophore communities
	Mobile Epifauna [2]	Mobile Gastropods	Nassariid communities, Turritellid communities
		Mobile Crustaceans	*Pagurus* communities
		Scallop Beds	*Argopecten* communities, *Placopecten* communities
		Sand Dollars	*Mellita* communities, *Clypeaster* communities
		Ophiuroids	*Ophiura* communities, *Ophiothrix* communities, *Amphiura* communities
		Holothurians	*Kolga* communities, *Stichopus* communities
	Infauna [3]	Clam Bed	*Macoma* communities, *Venus* communities, *Spisula* communities, *Mercenaria* communities, *Mya* communities, *Nucula* communities, *Yoldia* communities, *Mulinia* communities, *Rangia* communities, *Arctica* communities
		Tunneling Megafaun	*Squilla* communities, *Nephrops* communities, *Upogebia* communities, *Callianassa* communities, *Thallassia* communities
		Small Surface Burrowing Fauna	capitellid communities, oligochaete communities, lumbrinerid communities, *Leptocheirus* communities
		Deposit Feeders	*Nucula* communities, *Yoldia* communities, *Macoma* communities, Maldanid communities, *Clymenella* communities, *Pectinaria* communities
		Larger Deep-Burrowing Fauna	*Nephtys* communities, *Nereis* communities, nemertean communities
		Burrowing Urchins	*Echinocardium* communities, *Lovenia* communities
		Ophiuroids	*Ophiura* communities, *Ophiothrix* communities, *Amphiura* communities
		Echiurid Communities	*Urechis* communities, *Echiurus* communities
		Oligozoic	anoxic oligozoic areas, meiofaunal communities, bacterial communities
Aquatic Bed [AB]	Macroalgae [1]	Attached Ephemeral Macroalgae	mixed ephemeral macroalgae, *Ulva* communities, *Enteromorpha*

Class	Subclass	Biotic Group	Biotope
			communities, *Agardhiella* communities, *Chaetomorpha* communities, *Chordaria* communities
		Rockweeds	*Fucus* communities, *Ascophyllum* communities
		Leathery Red Macroalgae	*Chondrus* communities
		Kelp Forests	mixed kelp communities, *Macrocystis* communities, *Laminaria* communities, *Alaria* communities
		Leathery Green Macroalgae	*Codium* communities
		Jointed Calcareous Algae	*Corallina* communities, *Halimeda* communities
		Attached Crustose Algae	*Hildenbrandia* communities, *Phymatolithon* communities
		Rhodolith Bed	*Lithothamnion* communities, *Lithophyllum* communities
		Drift Ephemeral Algae	drift *Ulva*
		Drift Algae	drift kelp communities, drift rockweeds
	Rooted Vascular [3]	*Cymodocea - Thalassia* Seagrass Bed	*Cymodocea filiformis* Seagrass Bed
			Thalassia testudinum Seagrass Bed
		Halodule - Halophila Seagrass Bed	*Halodule wrightii* Seagrass Bed
			Halophila engelmannii Seagrass Bed
		Ruppia Seagrass Bed	*Ruppia maritima* Seagrass Bed
			Ruppia maritima Seagrass Bed
		Zostera Seagrass Bed	*Zostera marina* Seagrass Bed
		Phyllospadix Seagrass Bed	*Phyllospadix (scouleri, torreyi)* Seagrass Bed
	Microbial Mat [5]	Microphytobenthos	diatom communities, cyanobacterial communities
		Bacterial Mat	*Beggiatoa* mat communities
		Chemoautotrophic Bacteria	*Thiobacillus* mat communities
Emergent Wetlands [EM]	Coastal Salt Marsh [1]	Emergent High Salt Marsh	*Monanthochloe littoralis* Emergent Tidal High Salt Marsh
			Spartina patens - (Distichlis spicata) Emergent Tidal High Salt Marsh
			Spartina spartinae Emergent Tidal High Salt Marsh
			Schoenoplectus americanus Emergent Tidal High Salt Marsh
		Emergent Low Salt Marsh	*Spartina alterniflora* Tidal Low Salt Marsh
			Juncus roemerianus Tidal Low Salt Marsh
		Emergent Brackish Marsh	*Amaranthus cannabinus* Tidal Brackish Marsh
			Cladium mariscus ssp. jamaicense Tidal Brackish Marsh

Class	Subclass	Biotic Group	Biotope
			Sagittaria subulata - Limosella australis Tidal Brackish
			Schoenoplectus pungens Tidal Brackish Marsh
			Spartina alterniflora - Schoenoplectus robustus - Amaranthus cannabinus Tidal Brackish Marsh
			Spartina cynosuroides Tidal Brackish Marsh
			Typha (angustifolia, domingensis) Tidal Brackish Marsh
Scrub-Shrub Wetland [SS]	Coastal Salt Marsh [1]	Scrub-Shrub High Salt Marsh	*Baccharis halimifolia - Iva frutescens* Tidal Shrubland Alliance
		Scrub-Shrub Tidal Flat and Panne	*Batis maritima* Tidal Dwarf-shrub High Salt Marsh
			Borrichia frutescens Tidal Shrub-Scrub High Salt Marsh
			Sarcocornia pacifica - (Distichlis spicata, Salicornia spp.) Tidal Shrub-Scrub High Salt Marsh
			Sarcocornia pacifica - (Distichlis spicata, Spartina alterniflora) Tidal Dwarf-shrub High Salt Marsh
	Mangrove [2]	Scrub-Shrub Mangrove	*Rhizophora mangle* Tidal Mangrove Shrubland
Forested Wetlands [FO]	Mangrove [2]	Forested Mangrove	*Avicennia germinans* Tidal Mangrove Forest
			Rhizophora mangle Tidal Mangrove Forest
			Conocarpus erectus Tidal Mangrove Forest

Appendix D – Sub-Benthic Component

The structure of the Sub-Benthic Component is being developed by the MapCoast Consortium
The units within the Sub-Benthic Component are being developed by the MapCoast Consortium

Appendix E_1 – Water Column Component Classifiers

System	Depth Zones	Water Column Structure	Salinity	Temperature	Biotic Group	Biotope
Estuarine	Sea surface	Upper (mixed) water layer	Fresh	Frozen	Phytoplankton	(many)
Freshwaterinfluenced	Epipelagic	Pycnocline	Oligohaline	Superchilled	Zooplankton (includes icthyoplankton)	
Nearshore marine	Mesopelagic	Bottom water layer	Mesohaline	Cold	Floating microbial mat	
Neritic	Bathylpelagic	Benthic boundary layer	Polyhaline	Temperate	Floating macroalgae	
Oceanic	Abyssalpelagic	Non-stratified	Euhaline	Warm	Floating vascular vegetation	
Lacustrine	Hadalpelagic		Hyperhaline	Hot		

Appendix E_2 – Water Column Component Condition Assessment Parameters

Oxygen	Turbidity	Photic Quality	Trophic Status
Anoxic	Extremely turbid	Photic	Oligotrophic
Hypoxic	Highly turbid	Aphotic	Mesotrophic
Oxic	Moderately turbid	Seasonally photic	Eutrophic
Oxygen saturated	Clear		
Oxygen supersaturated	Extremely clear		

Appendix E_3 – Water Column Component Hydroforms

Hydroforms MANIFESTATION						
Coastal water mass	Density current	Entrainment	Hydrothermal plume	Internal wave	Salt wedge	Turbidity maximum
Downwelling	Divergence	Freshwater lens	Ice	Langmuir cell	Surf	Upwelling
Convergence	Cold core rings	Frontal boundary	Plunging current	Eddy	Surface foam	Warm core ring
Counter current		Groundwater seep	River/stream current	Oxygen minimum	Surface wave	
Current		Gyre		Plume	Turbidity current	

Appendix F – Geoform Component Classifiers

Physiographic Province	Code	Geoform (Natural)	Code	Geoform (Natural)	Code	Anthropogenic Geoform	Code
Fracture zone, spreading center	1	Apron, Deep fan, Bajada	A	Flank	F	Artificial reef	(a-r)
Mid-ocean ridge	2	Atoll	a	Flat, Floor, Seabed	f	Berm (anthropogenic)	(a-b/m)
Abyssal plain	3	Bank	m/f	Fracture, Crack, Crevice, Notch, Groove	_f	Dam, Dike	(a-g)
Oceanic bank (Plateau)	4	Basin	h	Hole, Pit, Scour Mark, Pockmark (non-karst)	h_e	Dredge deposit/Mound	(a-dm)
Continental, Island rise	5	Bay, Embayment, Sound, Bight, Fjord	q	Ice feature	i	Dredged channel, groove, trench or hole	(a-dg)
Continental, Island slope	6	Beach, relic (submerged)	b	Lagoon, Enclosed water	n	Drilling platform	(a-s)
Shelf break	7	Boulder(s)	h(b)	Landslide, Slump	l	Harbor, Marina	(a-m)
Continental shelf, island shelf	8	Canyon	c	Lava field	f_v	Jetty	(a-g)
Basin floor, borderland	9	Canyon head	c(h)	Ledge, Overhang	_d	Levee (anthropogenic)	(a-o)
Coast	10	Canyon mouth	c(m)	Moraine	i_m	Pier	(a-s)
Inland sea, Enclosed sea	11	Channel, Gully, Inlet, Tidal channel	g	Mound, Ridge, Knob	m	Seawall	(a-s/w)
		Channel bank	g/m	Overbank deposit, Levee (natural)	o	Shipwreck	(a-w)
		Delta, Fan	y	Pinnacle, cone	p	Trawl disturbance	(a-td)
		Depression	h	Rill (linear deposit or depression)	r	Scar/Prop scar	(a-f)
		Face	_i	Rock outcrop	e	Pilings	(a-s)
		Riverine Estuary	er	Shoal	sl	Archaeological feature	(a)
		Rubble zone	h(b)l_h	Slough	h/g		
		Sand ripple	_r	Solution pit, sink, karst	k		

Physiographic Province	Code	Geoform (Natural)	Code	Geoform (Natural)	Code	Anthropogenic Geoform	Code
		Scarp, Cliff, Fault, Slump scar	s	Fjord			
		Seamount	x	Sub-estuary	es		
		Seamount crown, crest, top	x(c)	Terrace, plain	t		
		Seamount base	x(b)	Terrace/Plain - volcanic	t_v		
		Guyot, Flat-topped seamount	x(f)	Trench (natural)	T		
		Guyot base	x/f(b)	Wall	(w)		
		Sediment/sand wave	w(w)	Vent	_e		
		Sediment/sand dunes	w(d)	Tidepool	u		

Appendix G – Geoform Estuary Types

It is known that many of the geomorphological and physical variables routinely measured or mapped naturally group together according to commonly recognized estuarine types (e.g., Madden et al. 2008). These types are sufficiently distinctive in geomorphology and hydrology as to represent estuaries that have different geoforms and also reflect significant differences in processes, such as nutrient cycling pathways, exchange with the ocean, fresh inflow and residence time. The concept of an estuarine type implies that a particular class of estuaries combines common ranges of several physical variables that tend to generally co-exist for each member of that class, foster similar responses in estuaries, and by which different types can be distinguished from each other. The understanding of how some general features of an estuary may be important determinants of estuarine response is both intuitive and based on an abundance of hard data. For example whether an estuary is well-flushed or river-dominated or poorly-circulated conjures an idea of the major characteristics of the light regime, oxygen regime, trophic status and even salinity regime. The concept of a geophysical classification underpins the importance of size and shape and flushing in dictating processes within an estuary.

The conceptual classification is drawn from a hierarchical framework for describing North American coastal and marine systems embodied in an EPA estuarine nutrient criteria project (Madden et al. 2008). A conceptual classification is the simplest kind of classification but can be a very powerful approach due to its simplicity. This approach uses a detailed set of quantitatively defined geomorphological, energy and biogeographic classifiers that fall into multiple categories. The variables considered in this scheme are those thought to be "natural" characteristics of the estuary, in both material and energetic terms, meaning those which influence estuarine processing to varying degrees and are not generally controllable or influenced by either stressor or response variables. They, and their modifiers, are organized into a simple framework of classes in a way that provides an efficient scheme for storing descriptive data for coastal systems.

The set of four major estuary types recognized in CMECS at the Geoform Level, including examples of subtypes, is as follows:

1) Riverine
   - River channel
   - Drowned river valley
   - Deltaic estuary
   - Salt wedge estuary
   - Tidal fresh marsh

This class of estuary tends to be linear and seasonally turbid, especially in upper reaches, and can be subjected to high current speeds. These estuaries are sedimentary and depositional, can be associated with a delta, bar or barrier island and other depositional features. These estuaries also tend to be highly flushed with a wide and variable salinity range and seasonally stratified. They have moderate surface to volume ratios with a high watershed to water area ratio and can have very high wetland to water area ratios as well. These estuaries are often characterized by a V-shaped channel configuration and a salt wedge.

High inputs of land drainage can promote higher levels of primary productivity that in the upper reach may be confined to the water column due to low water column transparency combined with greater depth. Surrounding wetlands may be extensive and healthy given the sediment supply and nutrient input. This marsh perimeter may be important in taking up excess nutrients that are introduced to the system. Physically the system may tend to be stratified during periods of high riverine input. The input of marine waters may be enhanced by countercurrent flow.

2) Lagoon

Coastal lagoon
Slough
Barrier Island estuary
Bar-built estuary
Tidal inlet

This class of estuary tends to be shallow, highly enclosed, with reduced exchange with the ocean, often experience high evaporation, and quiescent in terms of wind, current and wave energy. They tend to have a very high surface to volume ratio, low to moderate watershed to water area ratio and can have a high wetland to water ratio. The flushing times tend to be long relative to riverine estuaries and even embayments, as the restricted exchange with the marine end member and reduced river input lengthen residence times. As such, there tends to be more benthic-pelagic interaction, enhanced by generally shallow bathymetry. Additionally, exchange with surrounding landscapes, often riparian wetland and palustrine systems, tends to be enhanced and more highly coupled than in other types of estuary. The impact on nutrient processing may result in more recycling, more organic nutrient forms and more

3) Embayment

Bay
Sound
Coastal bight

This class of estuary is loosely bounded by enclosing landforms and open to marine exchange, with moderate to high salinities. They are well-flushed, often deep and subject to potentially high energy input from tides, winds, waves and currents. These estuaries can range from very low to very high in terms of surface area to volume, watershed to water area and wetland to water ratio.

4) Fjord

Fjords are deep, seasonally cold-water estuaries with low to moderate riverine inputs and exist at mid to high latitudes. This class of estuary has relatively complex, usually rocky shorelines and bottoms and is partially enclosed sometimes by mountainous landforms, often with a geologic sill formation at the seaward end due to formation by glacial action. The morphology combined with a low exchange of bottom waters with the ocean can result in formation of hypoxic bottom waters. Due to their depth they tend to have low surface area to volume ratios. They have moderate watershed to water area ratios and low to moderate wetland to water ratios.

Spatial Heterogeneity

In some cases, estuaries may exhibit two or more types, or have characteristics of different types in different parts of the estuary, tributaries or subestuaries. Resolution of these issues is ongoing and currently only the dominant type will be recognized in the list of Geoform units. Using statistical procedures, we intend to quantify the characteristic parameter spaces for multiple variables normally associated with these distinctive types.

Appendix H – Standard Attributes

Salinity	Enclosure	Position Relative to Shelf Break	Depth Zones	Percent Cover	Energy Type	Energy Intensity
Fresh	Unenclosed	Seaward	Shallow Infralittoral	Bare/Sparse	Wind	No Energy
Oligohaline	Partially enclosed	Landward	Deep Infralittoral	Moderately Sparse	Current	Low Energy
Mesohaline	Significantly enclosed		Circalittoral	Moderate	Surface Wave	Moderate Energy
Polyhaline	Very enclosed		Circalittoral (offshore)	Moderately Dense	Internal Wave	High Energy
Euhaline	Enclosed		Mesobenthic	Complete	Tide	
Hyperhaline	Intermittent		Bathybenthic			
			Abyssalbenthic			
			Hadalbenthic			

Energy Direction	Tide Range	Primary Water Source	Profile	Slope	Temperature	Anthropogenic Impact
Upward	Microtidal	Watershed	None	Flat	Frozen	Developed
Downward	Small Tidal Range	Local Estuary Exchange	Low	Sloping	Superchilled	Impounded/Diverted
Horizontal	Moderate Tidal Range	Local Ocean Exchange	Medium	Steeply Sloping	Cold	Dredged Area/Channel
Baroclinic	Large Tidal Range	River	High	Vertical	Temperate	Deposition
Seaward		Estuary		Overhang	Warm	Contaminated
Circular		Marine			Hot	Trawled/Harvested
Mixed						Restored Area
						Scarred
						Aquaculture

Rugosity	Oxygen	Turbidity	Photic Quality	Trophic Status	Temporal Persistence
Very Low	Anoxic	Extremely turbid	Photic	Oligotrophic	Low
Low	Hypoxic	Highly turbid	Aphotic	Mesotrophic	Medium
Moderate	Oxic	Moderately turbid	Seasonally photic	Eutrophic	High
High	Oxygen saturated	Clear			Permanent
Very High	Oxygen Supersaturated	Extremely clear			Variable
					Stochastic

Appendix I – Comparison of CMECS III Benthic Component to FGDC Wetlands Classification Standard

One objective for developing a national coastal and marine habitat classification standard was to provide common terminology. Many of the changes evident in CMECS Version III were made to better align CMECS with the existing wetland standard where possible and to ensure that like concepts and units in the two classifications are defined consistently providing for a seamless classification data layer from the continental divide to out beyond the continental shelves. A major benefit of aligning with the wetland standard is its proven utility and well defined protocols for mapping wetlands (National Wetland Inventory).

Although the wetland standard has been widely used for mapping U.S. freshwater and estuarine wetland systems, its application in marine systems has not been as widespread. In the coastal and marine realm, the wetland standard does not differentiate habitats sufficiently suitable for management purposes. CMECS departs from the wetland standard in several areas to address this need. Refer to the Table below for a comparison diagram.

Relationship between FGDC Wetland Classification Standard and CMECS Benthic Cover Component.

	Classification of Wetlands and Deepwater Habitats of the United States	Coastal and Marine Ecological Classification Standard
System	Marine	Nearshore (All)
	included in Marine	Neritic (All)
	included in Marine	Oceanic (All)
	included in Marine	Freshwater Influenced (All)
	Estuarine	Estuarine (All)
	Lacustrine	Lacustrine (All)
Subsystem	Intertidal	Intertidal (All)
	Subtidal	Subtidal (All)
Class	Unconsolidated Shore	Unconsolidated Shore (SGC)
	Rocky Shore	Rocky Shore (SGC)
	Unconsolidated Bottom	Unconsolidated Bottom (SGC)
	Rock Bottom	Rock Bottom (SGC)
	Emergent Wetland	Emergent-Low Shrub Wetland (BCC)
	Scrub-Shrub Wetland (SS)	*included in Emergent-Low Shrub Wetland*
	Forested Wetland (F)	Forested Wetland (BCC)
	Aquatic Bed	Aquatic Bed (BCC)
	not included	Faunal Bed (BCC)
	Reef	Coral Reef (BCC/SGC)
	included in Reef	Faunal Reef (BCC)
Subclass	Cobble/Gravel	Cobble/Gravel (SGC)
	Sand	Sand (SGC)
	Mud	Mud (SGC)
	Organic	Organic (SGC)
	included in Organic	Shell (SGC)
	not included	Mixed Sediments (SGC)
	Bedrock	Bedrock (SGC)
	not included	Pavement (SGC)
	Rubble	Boulder/Rubble (SGC)
	Persistent*	Coastal Marsh (BCC)
	Non-Persistent*	*included in Coastal Marsh*
	Needle-Leaved Evergreen (SS)	*included in Coastal Marsh*
	Broad-Leaved Evergreen (SS)	*included in Coastal Marsh*
	Needle-Leaved Deciduous (SS)	*included in Coastal Marsh*
	Broad-Leaved Deciduous (SS)	*included in Coastal Marsh*
	Dead (S)	*not included*
	included in Scrub-Shrub Wetland	Tidal Shrubland (BCC)
	Needle-Leaved Evergreen (F)	*reflected in Group and Biotope levels*
	Broad-Leaved Evergreen (F)	Mangroves (BCC)
	Needle-Leaved Deciduous (F)	*reflected in Group and Biotope levels*
	Broad-Leaved Deciduous (F)	*reflected in Group and Biotope levels*
	Dead (F)	*not included*

	Algal	Macroalgae (BCC)
	Rooted Vascular	Rooted Vascular (BCC)
	not included	Microbial Mat (BCC)
	Aquatic Moss	*not included*
	Floating	*included in Water Column Component*
	Mollusk	Mollusk Reef (BCC)
	Worm	Worm Reef (BCC)
	Coral	Coral Reef (SGC/BCC)
	included in Coral	Lagoon (SGC)
	included in Coral	Back Reef (SGC)
	included in Coral	Reef Flat (SGC)
	included in Coral	Reef Crest (SGC)
	included in Coral	Forereef (SGC)
	included in Coral	Deep Forereef (SGC)
	included in Coral	Pinnacle Reef (SGC)
	included in Coral	Mesophotic Reef (SGC)
	included in Coral	Deep/Cold Water Reef (SGC)
	included in Coral	Living Stony Coral Communities (BCC)
	included in Coral	Coral Colonizers (BCC)
	included in Coral	Calcareous Algal Communities (BCC)
	included in Coral	Non-Calcareous Algal Communities (BCC)
	not included	Sessile Epifauna (BCC)
	not included	Mobile Epifauna (BCC)
	not included	Infauna (BCC)

* Emergent Wetland Persistence addressed through CMECS descriptor/modifier

Appendix J - Ecoregions for the United States

Adapted from Marine Ecoregions of the World (Spalding et al. 2007)

12. Beaufort Sea—continental coast and shelf
13. Chukchi Sea
14. Eastern Bering Sea
39. Scotian Shelf
40. Gulf of Maine/Bay of Fundy
41. Virginian
42. Carolinian
43. Northern Gulf of Mexico
53. Aleutian Islands
54. Gulf of Alaska
55. North American Pacific Fijordland
56. Puget Trough/Georgia Basin
57. Oregon, Washington, Vancouver Coast and Shelf
58. Northern California
59. Southern California Bight
70. Floridian
152. Hawaii